POWER PLANT ENGINEERING

Established Over 35 Years

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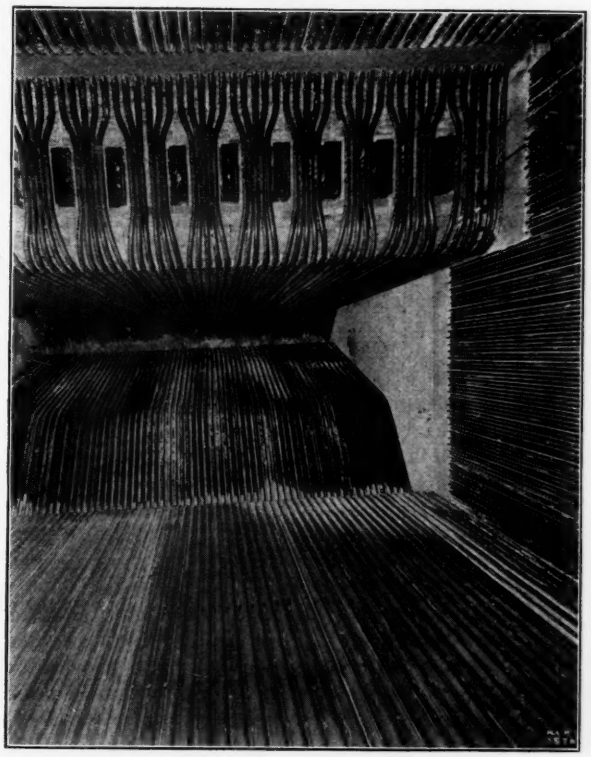
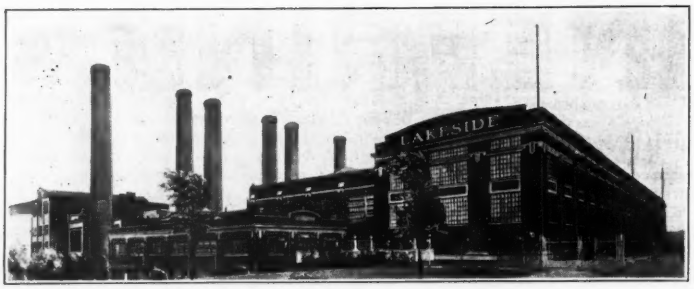


Into the Maw of Moloch

TEMPLES TO the unseen god, Electricity, dot the entire civilized world. Scarcely a hamlet but can point (we hope with pride) to the local shrine of this modern Moloch with its altars for burnt offerings and an insatiable appetite for the firstborn.

Moloch was a more or less legendary god or idol of the ancients with a fiery maw into which sacrifices or offerings were cast, the tradition being that these offerings must be the firstborn. The modern Moloch in thousands of Temples of Power is much more awesome than its legendary predecessor and just as exacting in demands for the firstborn—in the form of the first increment of steam or power for auxiliaries.

More commonly we refer to these temples as power plants and the Moloch as a boiler. Above is boiler No. 19 at Lakeside station where power plant history was made. The camera was pointed straight up and the sinister eyes looking outward are in reality pointed straight down. The deep mouth of the picture is the throat of the furnace. More details of this station and boiler are given in the article which begins on the next page.



LAKE

A Decade

Now Up to Its Ultimate Capacity, Lakeside Station, Built at a Cost of $80 per Kilowatt of Capacity, Has Played a Dominant Part in the Power Plant Industry Since 1920. A Reduction in Heat Rate from 21,000 B.T.U. per Kw-hr. in 1921 to About 13,500 in 1931 Is Evidence of the Successful Fight Waged Against Obsolescence.

ALWAYS A PIONEER, Lakeside Station of The Milwaukee Electric Railway & Light Co., has, for more than 10 yr., maintained its position as an outstanding leader of the power plant field. Backed by an uncanny intuition, sound experience and a capable operating department, the company has pioneered in practically every major development during the past decade. A record of Lakeside Station reads more like a composite story of the industry than like a history of a single plant.

Launched in 1920 as the first all-pulverized fuel central station[1, 2] Lakeside hardly waited for confirmation of the success and practicability of pulverized coal throughout the world before jumping into high pressures[3, 4, 5] with the reheat cycle and radiant superheaters and reheaters.

These steps required the development of an operating procedure[6, 7] and control[5] far in advance of that needed before. Resulting investigations into the chemical[5] and metallurgical fields[8] have been well covered in the past and do not need repeating here. The spirit of these investigations is illustrated by the action taken when oxygen was found to be responsible for high-pressure tube failures. Not content with the elimination of all but the usual "trace of oxygen" the order went out that there shall be "no oxygen" in the feedwater. The use of ferrous hydroxide resulted in no oxygen in the feedwater from one month to the other.

Developments

Of the major developments, Lakeside can be credited with pioneering in pulverized coal, high pressures and radiant superheaters. The first two are well established throughout the industry; the last is widely used[8] and its superior operating characteristics are bound to gain further recognition as high pressure and high temperature become more universally adopted. Of the minor developments[9], the use of flue gas for mill drying and the location of the exhauster fan on the inlet side of the

Footnotes, except [8], refer to back issues of Power Plant Engineering

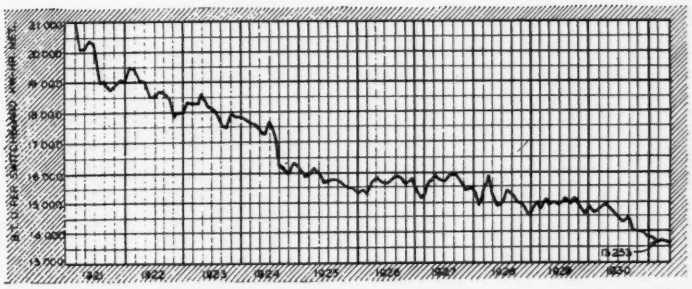
[1]Lakeside Power Station at Milwaukee; p. 397, April 15, 1922
[2]Lakeside Plant visited by A.S.M.E.; p. 638, June 15, 1921
[3]1200 lb. Turbine shows 80 per cent Efficiency. p. 1186, Nov. 15, 1927
[4]See Heat Balance & Tabulated data; p. 1300-1339, Dec. 15, 1927
[5]Opera. Exp. with 1300-lb. pressure; p. 229, Feb. 15, 1928
[6]Instrument selection should receive attention; p. 841, Aug. 1, 1927
[7]See Fig. 1-7 Appurtenances for use with 1200-lb. boilers; p. 1250, Dec. 1, 1927
[8]See Radiant Superheater Developments by M. K. Drewry before A.S.M.E. at Hartford, Conn., June, 1931

TABLE I. TRENDS OF DESIGN AS SHOWN BY DATA COVERING A PERIOD OF 10 YR.

Boiler room No.	1	2	3	
Constructed	1920	1924	1926	1929-30
Number of boiler-units	8	8	1	3
Normal steam output, lb. per hr.	72,000	112,500	240,000	250,000
Normal kw. output per boiler	7,200	11,250	31,000	32,300
BOILERS				
Manufacturer	Edge Moor	Edge Moor	B & W	C. E. Co.
Size, sq. ft.*	13,330	18,280	30,590	28,920
Type	Hor. water tube	Hor. water tube	Stir-ling	Bent tube
Number of drums	5	6	3	3
Max. press. lb.G	317	317	1390	1390
Av. Operating press, lb.G	305	305	1250	1300
Water content, lb.	104,600	140,500	92,000	90,000
Evaporation of storage water, times per hr	0.69	1.08	2.6	2.8
Size, in. O.D.	4 in.	4 in.	3 in.	3 in.
Thickness, in.	.172	.172	.312	.312
Number	563	638	1602	1473
Feedwater temp. deg. F.	200	200	325	350
FURNACE				
Volume, cu. ft.	6450	12,000	30,100	28,573
Water screens and walls, sq. ft.	270	630	1,544	5,420
Normal coal burned lb. per hr.	7,600	12,000	25,000	26,000
B.t.u. of coal, as fired	12,800	12,800	12,800	12,800
B.t.u. released per cu. ft. of furnace volume per hr.	15,100	12,800	10,600	11,650
Side Walls	Air-cooled	Air-cooled	Steam-cooled	Steam-cooled
Material	Brick	Brick	Rad. Suph.	Rad. Suph.
Rear Wall	½ Steam-cooled	Steam-cooled	Steam-cooled	Water-cooled
Material	Rad. Suph.	Rad. Suph.	Radiant Reheaters	Fin tubes
Front Walls	Brick	Brick	Fin tubes	Fin tubes
Furnace width, ft.	24	27½	35	35
Furnace height (ave.), ft.	20	20	26	26
Furnace horiz. depth, ft.	13.5	20	23	23
Approx. mean furnace temperature, deg. F.	2100	2100	2100	2100
SUPERHEATERS AND REHEATERS				
Superheaters, kind	Convection	Radiant	Radiant	Radiant
Superheater surface, sq. ft. Radiant	4024	418	910	902
Superheater surface, sq. ft. Convection	144			
Reheater, kind	None	None	Radiant	Convection
Reheater, surface, sq. ft.	None	None	690	7800
FLUE GAS HEAT ABSORBING EQUIPMENT				
Kind	Economizer	Economizer	Air heater	Air heater
Area, sq. ft.	7603	13,824	75,000	77,500
Ratio to boiler surface	.57	.756	2.45	2.68

*Including water walls

SIDE-
of Progress



ABOUT 75 PER CENT OF THE OUTPUT OF THE STATION IS NOW GENERATED FROM HIGH PRESSURE STEAM. PULVERIZED COAL FIRING; RADIANT SUPERHEATERS AND REHEATERS; HIGH PRESSURES; REHEAT CYCLE; FLUE GAS MILL DRYING; SMOKE WASHERS; AND EXHAUSTERS ON THE INLET SIDE OF THE PULVERIZING MILL WERE PIONEERING DEVELOPMENTS.

pulverizing mill where it handles little coal dust are improvements to which Lakeside contributed.

In the development of the mercury cycle, slag tap furnace, and the unit system, Lakeside had no part and although Lakeside engineers recommend them for certain conditions, they point to their own operating results: not less than 90 per cent high-pressure boiler availability; a fluffy deposit and no slag in the ashpits; control of uniform superheat and reheat from full to quarter load without complicated equipment; one boiler unit per high-pressure turbine; four hours pulverized coal supply in case of mill outage, all for $80 per kw. installed, exclusive of step-up stations.

TRENDS OF PRACTICE

Trends of practice as summarized by the changing designs of the three Lakeside sections are shown by the tabulation. Boiler pressures have increased 4.4 times, from 317 to 1390 lb. ga.; total steam temperatures have increased from 611 to 750 deg. F. (the original temperature of 611 in the first section was later raised to 700 deg. F. by the addition of radiant superheaters); boiler sizes measured in square feet increased 2.17 times, based on steaming capacity 3.47 times and based on kilowatt output 4.5 times. These last ratios indicate both the increased steaming rates of the new boilers and the lower water rates of the newer turbines. An interesting sidelight on the rapid and consistent development of boiler sizes is shown by Fig. 5, a graphic record of boiler growth over a period of 20 yr. in three stations. Port Washington, the latest development of the company, is now under construction just north of Milwaukee.

TABLE II. TURBINE ROOM DATA

Turbines	1, 2	3, 4, 5	6	9	11	7, 8, 10, 12
Manufacturer.	G. E.	G. E.	G. E.	West.	A. C.	G. E.
Installed.....	1920	1923-4-5	1926	1929	1930	1926-9 1930-30
Capacity kw. each*	20,000	30,000	30,000	60,000	60.000	7,700
STEAM CONDITIONS						
Operating Press lb. G.	285	285	285	285	285	1,250
Operating Temp. deg. F.	700	700	700	700	700	735
Exh. Press...	1 in.	1 in.	1 in.	1 in.	1 in.	300 lb. G.
EXTRACTION HEATERS						
Number of heaters ...	1	1	4	4	4	0
Final feed temp. deg. F.	160	160	325	350	350	
CONDENSERS						
Manufacturer.	...	All Foster Wheeler			"	None
Number of passes	3	3	1	1	1	
Sq. ft.	35,000	50,000	25,000	55,000	55,000	
G.P.M. of pumps	36,000	50,000	50,000	105,000	105,000	

*Total plant capacity 310,800 kw.

BOILERS

It is interesting to note from Fig. 5 that the single boiler of the Port Washington plant will generate as much electricity as 48 of the Commerce St. boilers installed in 1900, therefore twice as much as two Commerce St. plants of 24 boilers each. Boiler outputs have doubled every 4 yr. and if continued at the same rate would bring 200,000-kw. boilers by 1940. This would mean about 1,600,000 lb. of steam per hr., a figure well within the bounds of probability if load conditions can be increased to the point where units of this size can be used to advantage.

As pressure increases, the water content of the boiler drums tends to decrease because of the added cost. This change is shown by a comparison of the old and new boilers where in spite of an increase of 2.17 times in boiler size, the water content has decreased to 86 per cent of its 1920 value and the time in which evaporation

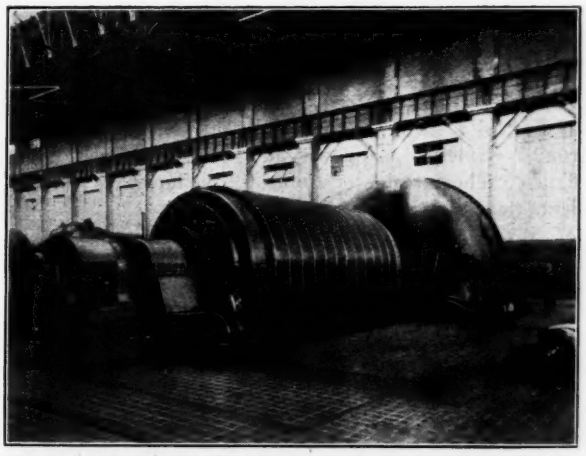


FIG. 1. TURBINE UNIT NO. 11, THE LAST 60,000 KW. UNIT INSTALLED

of a boiler full of water now takes place is 21.4 min. instead of 87 min.

Furnaces

Furnace volumes have increased slightly to expose sufficient radiant heating surface for moderate furnace temperatures and the air-cooled refractory furnace walls of 1920 have given place to steam-cooled side walls with the remaining walls, top and bottom, water-cooled. This increase in furnace size has caused a decrease in the unit heat, release but increased preheat in the combustion air has resulted in approximately the same mean furnace temperatures in spite of the fact that in the new boilers 60 per cent of the total heat released by the coal is absorbed before the gases enter the boiler.

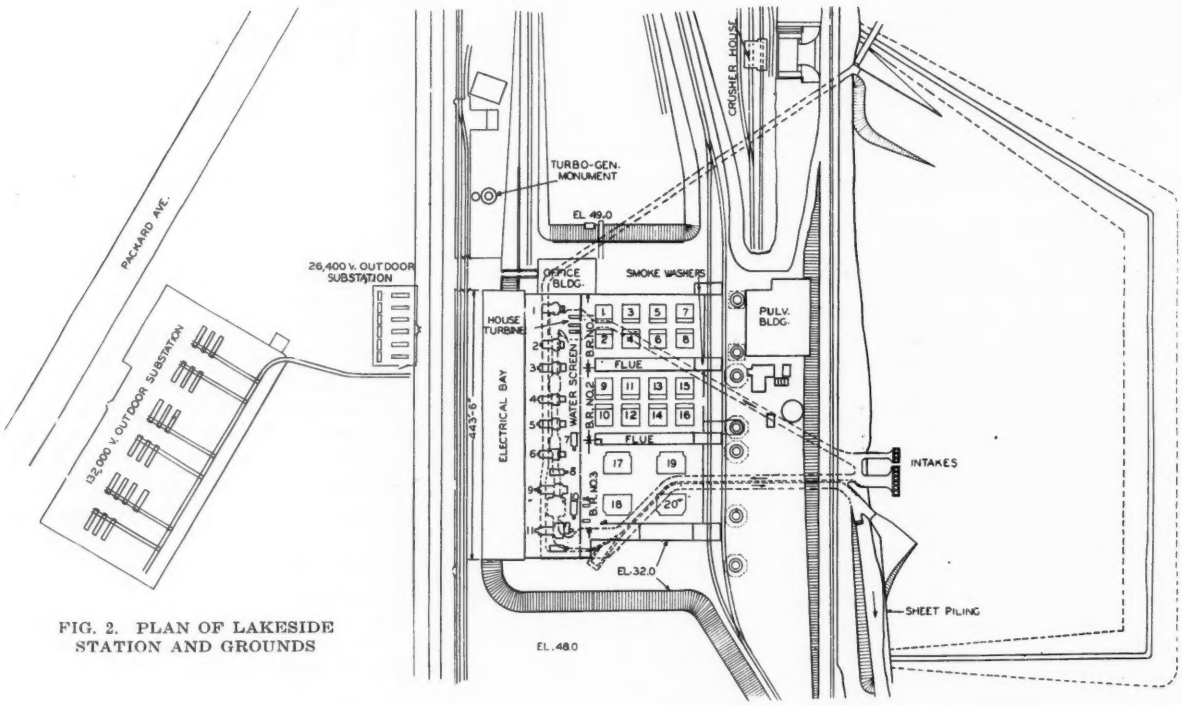


FIG. 2. PLAN OF LAKESIDE STATION AND GROUNDS

Superheaters have changed from convection to the radiant type, even the original convection elements of the No. 1 boiler room being assisted by radiant boosters. Cast and forged flat-faced elements as shown at the left of Fig. 11 were first used but were later replaced with round elements as shown at the right of the same figure[8]. The interior of Boiler 19 is shown on the contents page.

Extraction heating has increased feedwater temperatures from 140 to 350 deg. F. and has resulted in a change from economizers to air heaters.

Turbines

Radical changes have also taken place in the turbine room. Low pressure turbine sizes have increased three fold. Instead of the ultimate capacity of 200,000 kw. originally planned[1] the capacity is actually 310,800 kw. In 1920, 35,000-sq. ft. three-pass condensers were installed under the 20,000-kw. turbines. In 1929, a 55,000-sq. ft. single pass condenser was installed under a 60,000-kw. turbine. This was a reduction of from 1.75 to 0.915 sq. ft. per kw. A direct comparison of the single and three-pass design is given by the 30,000-kw. unit 5, installed in 1925 with a 50,000-sq. ft., three-pass condenser and the 30,000-kw. unit No. 6, installed in 1926 over a 25,000-sq. ft., single-pass condenser. Better condenser performance and more extraction heating warranted this decrease in size.

Coal Preparation

Perhaps the most radical change has been in the coal preparation method. Originally coal was dried in separately fired rotary coal dryers and pulverized in a central preparation house outside of the power plant. It is shown at the extreme left of the exterior photograph in the headpiece. Mills had a capacity of 6 t. per hr. In the No. 3 section, 15-t. mills are located immediately in front of the boilers, with the exhausters on the suction side of the cyclone separators so that they handle practically no coal. Flue gas is used for drying the coal and is then vented to the stacks. This drying system eliminates the old separately fired dryers and increases the plant efficiency one per cent. Raw coal bunkers are located above the center of the firing aisle with smaller pulverized coal bunkers on the sides.

Practical results of this progressive policy during the lifetime of the station are shown by the performance curve in the headpiece. From 21,000 B.t.u. per net kw.-hr. in 1921, the heat rate has continually dropped until at present it is near 13,500. The effect of a new

boiler room with radiant superhearters is evident from the 1500-B.t.u. drop in the middle of 1924 and the effect of the first high pressure unit is shown by the drop during the latter part of 1927. The peak in the spring of 1928 was caused by the outage of the high-pressure turbine for a couple of months following its initial period of operation[5]. At present about 75 per cent of the output of the station is generated with high pressures.

Early History

Lakeside was first planned in 1916 and the site selected about a mile south of the Milwaukee city limits. The war, however, made it necessary to suspend work and it was not until December, 1919, that orders were issued to proceed. During the intervening period, experimental work carried on at Oneida Street Station[10] convinced the company that they would be justified in designing and building the plant for pulverized fuel instead of for stokers as originally planned.

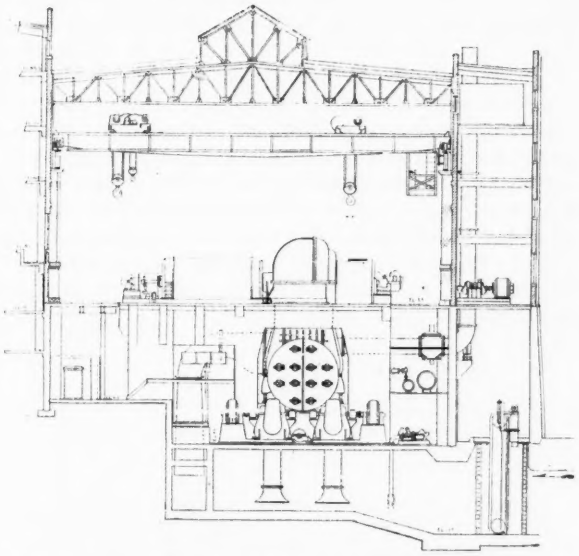


FIG. 3. CROSS SECTION THROUGH THE TURBINE ROOM

Construction work was carried on simultaneously with engineering work and on December 15, 1920, the first 20,000-kw. unit was put into service[2]. The initial installation consisted of eight 13,060-sq. ft. Edge Moor longitudinal drum boilers arranged in two rows as shown in Fig. 2 and two 20,000-kw., 13,200-v., 3-ph., 60-cycle turbine units each with 35,000-sq. ft. three-pass condensers with two 18,000 g.p.m. (1 turbine and 1 motor driven), 24-in. circulating pumps, a motor driven condensate pump, a turbo air pump and a steam-jet air pump.

Arrangements of the boilers in this section are shown by Fig. 7. Each boiler, with a furnace volume of 6450 cu. ft., was fired by six burners, the gases passing through the four passes of the boiler to the 7603-sq. ft. economizer and turbine-driven induced draft fan to the flue. These flues were concrete, 8 ft. high and from 11 to 18 ft. wide, located below the economizer and leading to the bases of 15-ft. by 200-ft. concrete stacks, each stack serving four boilers. Side walls were air-cooled

[10]Successful pulverized coal installation; p. 313, Mar. 15, 1920

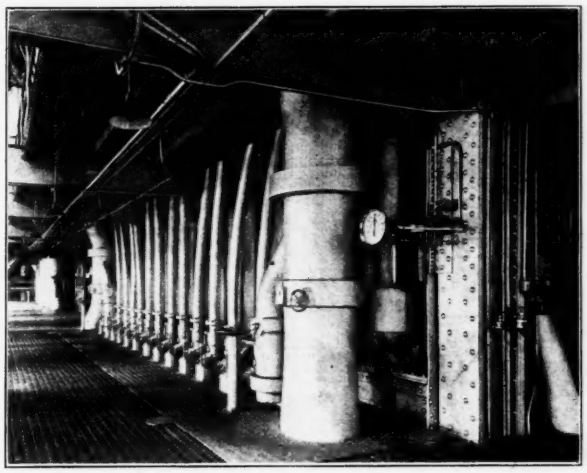


FIG. 4. VIEW ON THE HIGH-PRESSURE BOILER FIRING FLOOR

and a water screen was later installed just above the flat furnace floor.

Condensate and returns were pumped to an overhead gravity supply tank and flowed downward through open heaters and a V-notch meter to the suction of the 6 in. (400 g.p.m. and 650 g.p.m.), boiler feed pumps. Three of the pumps were turbine driven and two motor driven. Heat balance conditions were maintained by the steam driven induced draft fans and operation of the motor or turbine driven boiler feed and circulating pumps as conditions demanded, leaving the exact regulation of the feedwater temperature up to the 500-kw. house unit or heat balancer.

Under normal conditions, each generator was excited by its own 240-v. exciter but was automatically connected to the auxiliary supply bus in an emergency. This auxiliary bus was fed by two 300-kw. motor generator sets, with a storage battery reserve. The system also took care of the direct-current auxiliaries such as cranes,

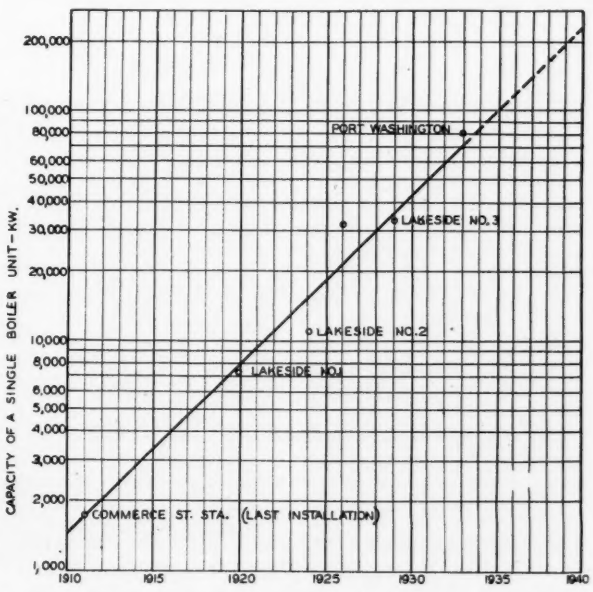


FIG. 5. BOILER GROWTH AS REFLECTED BY THE PROGRESS OF ONE COMPANY

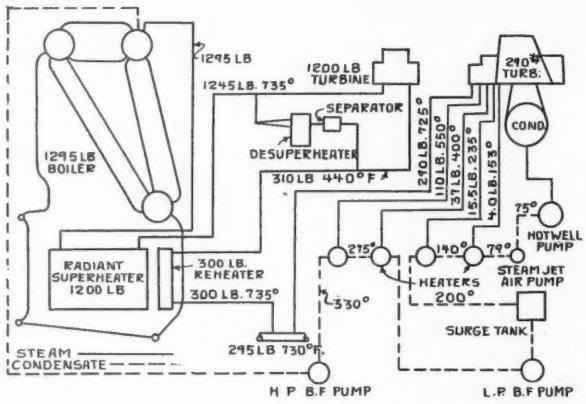


FIG. 6. FLOW DIAGRAM OF THE FIRST HIGH-PRESSURE UNIT

motor operated valves, car dumper, coal feeders and magnetic pulleys. Alternating current auxiliaries were supplied with 480-v. current either through a bank of transformers from the main generators or from the 500-kw. house turbine.

Current generated at 13,800 v. left the station, without being transformed, through underground cables leading to the outdoor substation where some of it was stepped up to 26,400 v. Generators were cooled by the open system with spray washers, the warmed air being discharged into the boiler room.

In the switchhouse were two main 13,200-v. bus bars, the east and west as in Fig. 13. Each generator fed its own section of the bus and these sections were tied together through reactors to form a ring bus. The switchhouse is divided longitudinally, with each group of compartments isolating two busses from each other to prevent phase to phase shorts. The original sections 1 and 2 are without fault protection but the remaining sections are arranged to isolate all current carrying capacity at generator voltage.

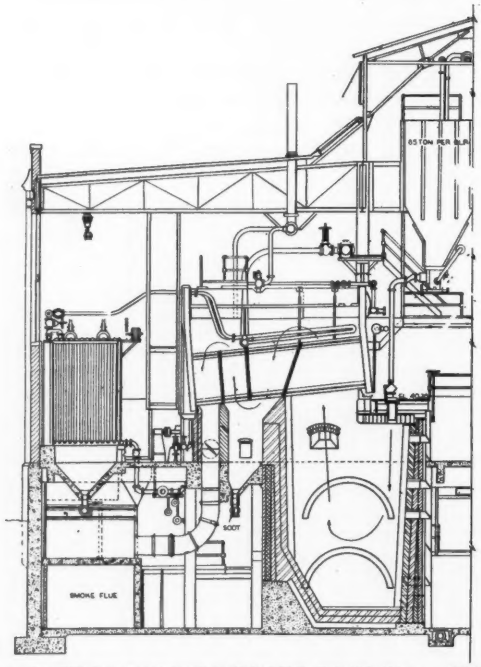


FIG. 7. SECTION THROUGH BOILER ROOM NO. 1—BOILERS 1 TO 8

Circulating Water and Plant Site

Circulating water is obtained from Lake Michigan, the intake tunnel terminating near the shore line and being protected by a 1763-ft. long rubble mound. Concrete intake tunnels 10 ft. in dia. extend under the boiler room as shown in the plan, the traveling screens being located between the boiler room and turbine room as shown by Figs. 2 and 3. The discharge tunnel is arranged to discharge inside or outside of the basin formed by the rubble mound so as to prevent freezing of the pond in winter time. Originally the discharge was at the north end of the pond, but with the extension of the plant southward, the south tunnel was built and now water can be discharged at either end of the pond so as to take advantage of the lake currents and wind to obtain cooler water in summer. The present tunnels are sufficient for an additional 160,000 kw. and are available for a new station to the south of the present site.

Because of the 50-ft. bluff along the lake it was necessary to excavate considerably in order to bring the condensers down and eliminate excessive circulating pump heads. The deepest excavation was about 20 ft. below the lake level, placing the condenser floor at elevation +1 and the boiler and turbine room floor at +33 or about 16 ft. below the ground level, as indicated in Fig. 3. Thus, although the station is approximately 90 ft. from condenser floor to ceiling, only about 40 ft. of the station is visible above ground.

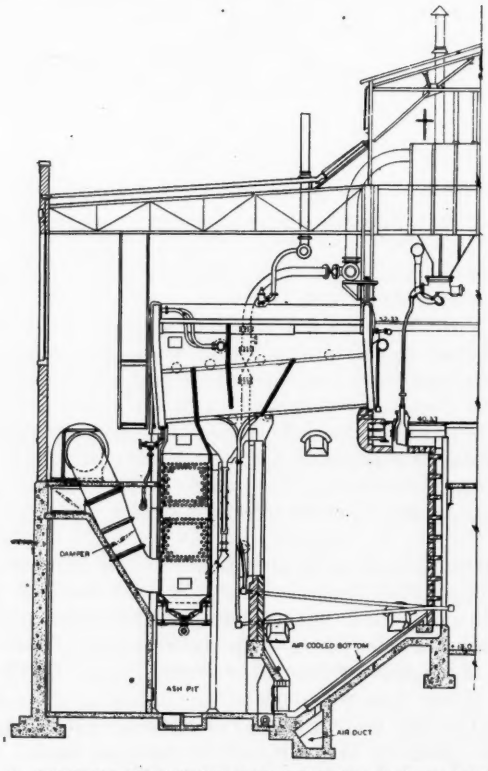


FIG. 8. SECTION THROUGH BOILER ROOM NO. 2—BOILERS 9 TO 16. ECONOMIZER AND FAN ARRANGEMENT CHANGED. RADIANT SUPERHEATERS USED.

Coal is received at the plant over the company's private track, emptied by a Robins car dumper, crushed and then elevated to the bunkers by an inclined belt conveyor. The original preparation house measured 108 by 125 ft. and had equipment for 80,000 kw. Three separately fired, rotary 16 t. per hr. Fuller Lehigh dryers were installed to dry the coal for eight 6-t. mills. Pulverized coal was transported by Fuller-Kinyon pumps.

Original Plans

It was originally planned to have an ultimate capacity of 200,000 kw. in three sections; the initial 40,000 kw. and two additional sections of 80,000 kw. each. The final boiler room was to consist of three sections with a total of twenty-four 1306-hp. boilers, all of which would have had to be operated at 250 per cent in order to carry the full 200,000-kw. load.

Second Section

Actually, the second section consisted of eight 18,280-sq. ft. boilers and three 30,000-kw. turbo-generators. Boilers were changed somewhat as shown by Fig. 8 and by the installation of radiant superheaters. Outside of this no radical changes were made although the direct connected exciters on these later units are connected in parallel with the direct current auxiliary bus as emergency supply as before. The circuit breakers on the two supplies are interlocked so that both breakers cannot be opened at once.

Third Section

Next came the 1300-lb. boiler, No. 17; turbine unit No. 6, a 30,000-kw., 300-lb. machine; and turbine unit

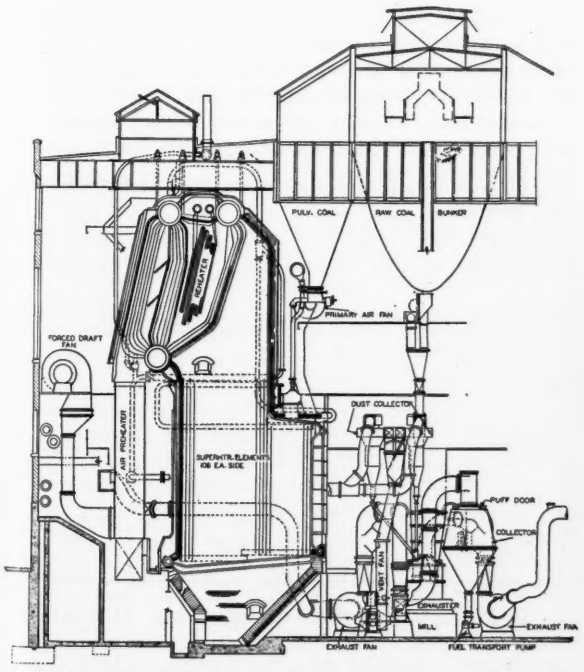


FIG. 9. SECTION THROUGH BOILER ROOM NO. 3—BOILERS 18 TO 20

No. 7, the first 1200-lb. turbine rated at 7000-kw., 90 per cent power factor. With unit No. 6, the three-pass condenser was abandoned in favor of the single-pass, making it possible practically to halve the condenser size. As with units No. 3, 4 and 5, two motor driven circulators were supplied and the open system of generator cooling continued but two motor driven hotwell pumps were used instead of a single unit and four stages of extraction utilized.

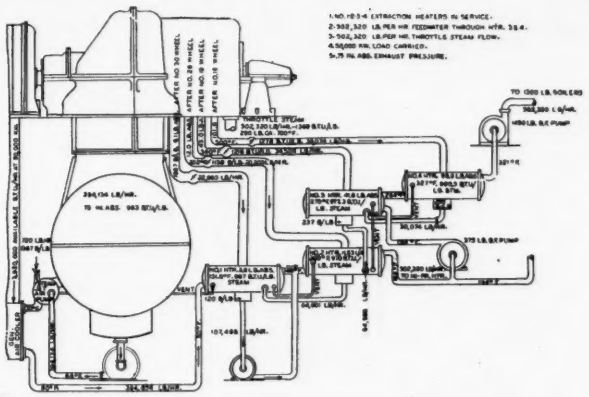


FIG. 10. HEAT BALANCE OF THE LATEST 60,000-KW. TURBINE

First High Pressure Boiler

The new boiler was a 30,590-sq. ft. Stirling with a furnace volume of 30,100 cu. ft. and fired by turbulent burners pointing downward. Fuel was supplied from the central preparation house. The economizer was replaced by an air heater. Side walls consisted of 910 sq. ft. of radiant superheater; the rear wall of 690 sq. ft. of radiant reheater; with a front wall and water screen totaling 1544 sq. ft. of water-cooled surface. The radiant elements were of the flat-faced forged type as shown at the left of Fig. 11, the arrangement of the boiler and furnace was almost identical with Fig. 9, the only difference being the arrangement of the reheater. The flow diagram of the first high-pressure unit is shown by Fig. 6, steam from the high-pressure boiler passing through the high-pressure turbine back to the high-pressure boiler for reheating and then on to the 300-lb. station header.

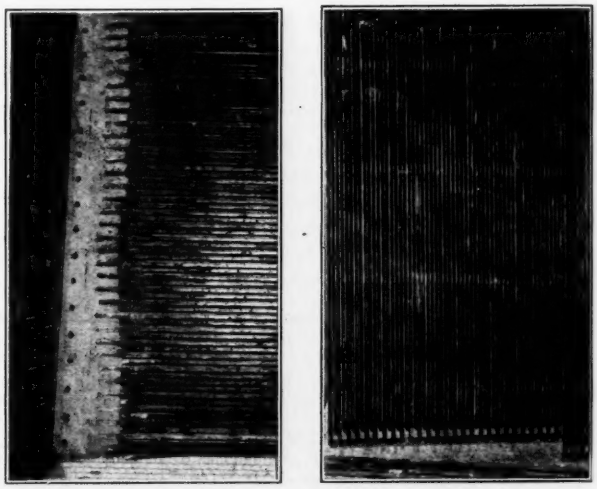


FIG. 11. (LEFT) ORIGINAL FLAT FACED FORGED RADIANT ELEMENTS (RIGHT) NEW TYPE ROUND RADIANT ELEMENTS

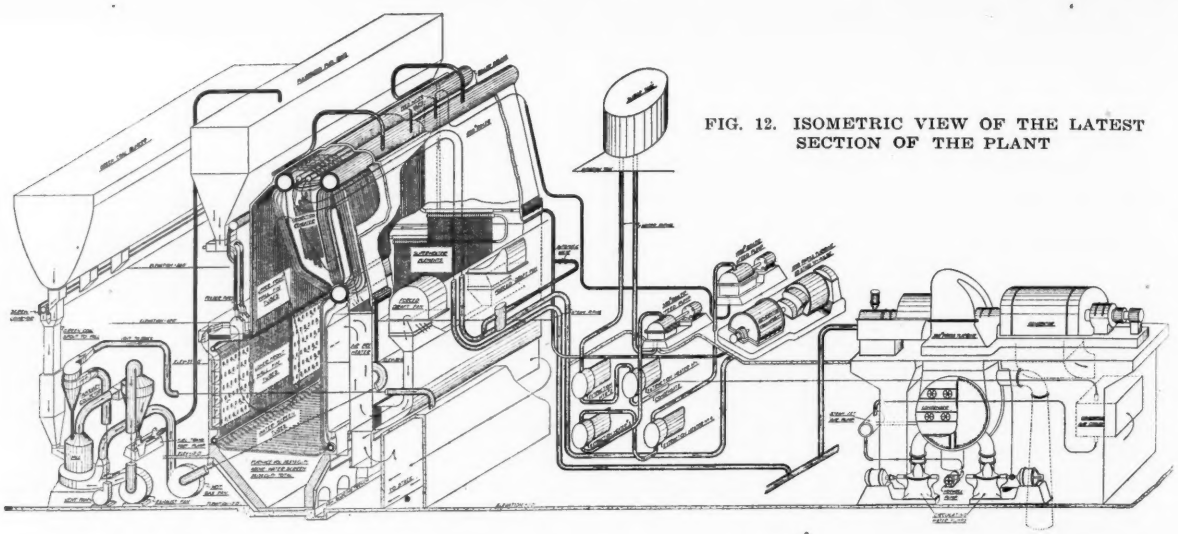


FIG. 12. ISOMETRIC VIEW OF THE LATEST SECTION OF THE PLANT

Reheaters

Operating against a constant back pressure, the exhaust temperature of the high-pressure turbine increases as the load decreases[8]. The radiant reheater has the same type of characteristic, making the combination an undesirable one for other than base-load operation. In the second high-pressure boiler unit No. 19, the radiant reheater was replaced with a convection reheater as shown by Fig. 9, resulting in practically a constant reheat temperature from quarter to full load. (When a high-pressure turbine operates as part of a compound unit, the exhaust pressure from the high-pressure section is variable and the exhaust temperature decreases with load, making the radiant reheater characteristic a desirable one. The new boiler at Port Washington will have a radiant reheater.)

Experiments with round radiant heating elements showed that they were just as effective, much lighter and cheaper than the forged flat-faced elements formerly used so that they were used in the second high-pressure boiler and are rapidly replacing the forged elements in other parts of the plant. The appearances of these round elements are shown by the right-hand side of Fig. 11 and by the photograph on the contents page.

Another innovation was the location of the pulverizing mill in front of the new boiler instead of in a central preparation house and the use of flue gas for coal drying in the mill[9]. Later the original bin arrangement of the first high-pressure boiler No. 17 was changed to conform to the later arrangement.

Installation of a second high-pressure turbine No. 8 rated at 7700 kw. and a 60,000-kw., low-pressure unit No. 9 raised the station capacity to 234,700 kw. This was followed by the installation of two more high-pressure boiler units, No. 18 and No. 20, similar to boiler No. 19; two more high-pressure turbines No. 10 and 12 each rated at 7700 kw. and another 60,000 kw. low-pressure turbine No. 11. Both of these new low-pressure turbines are bled at four points, a heat balance of the last unit being shown by Fig. 10. An isometric view of the high-pressure boiler and turbine, low-pressure turbine, condenser and heaters is shown by Fig. 12.

The complete station now has a total of fifteen boiler feed pumps, all of the later ones being motor driven as are all the auxiliaries in the last sections. Five high-pressure boiler feed pumps (one for each boiler and

[9]Mill Drying coal with 350 deg. F. Flue gas; p. 376, Apr. 1, 1930

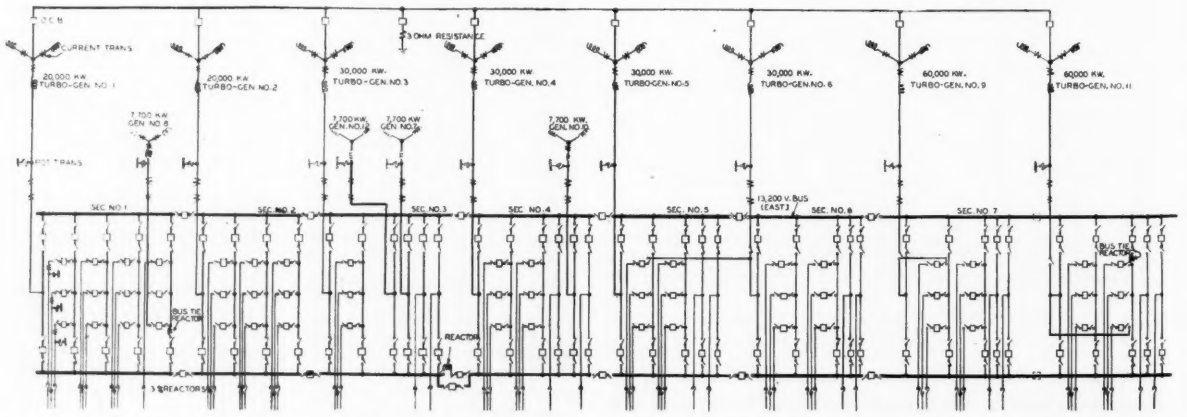


FIG. 13. SINGLE LINE ELECTRICAL DIAGRAM OF LAKESIDE STATION

one spare) take their suction from the low-pressure boiler feed line at the discharge pressure of the low-pressure boiler feed pumps.

Transmission System

Some of the power generated is stepped up to 26,400 v. in a bank of six 10,000-kv-a., three-phase transformers and part is transformed up to 132 kv. and sent out over three overhead lines to different parts of the system which is tied in with the Public Service Co. of Northern Ill. at the Illinois-Wisconsin line; with the Wisconsin-Michigan Power Co. at Appleton and with the Wisconsin Power & Light Co. at Plymouth.

Lakeside was built by the Wisconsin Electric Power Co. from the designs of The Milwaukee Electric Railway and Light Co. engineering department and leased to the latter company for a term of years extending to 1956. The total cost of the station was $25,972,000, making a unit cost of $83.50 per kw. of capacity, including the cost of the transmission substation across the road.

Boiler No. 20 and turbine Nos. 11 and 12 contemplate the station to its ultimate capacity. For the next 10 yr. or so, activities of the company will be centered at the Port Washington Station now under construction just north of Milwaukee. If at the end of that time continued load increases demand additional capacity, it is probable that Lakeside No. 2 will be started just south of the present Lakeside Station as the plant site has a lake frontage of 6000 ft. sufficient for one or even two more plants. Although the activities of the company may shift to Port Washington for eight or ten years, system growth and load conditions will cause an eventual resumption of activities at Lakeside. We can look back over what is probably the most colorful chapter in power plant history, confident that in the future Lakeside will continue to play an important part.

The Single-Pass Boiler and Its Economic Field

New Straight Tube Single Boiler With No Economizer, Air Heater or Induced Draft Fan Fills Need for High Efficiency and High Availability. By Otto de Lorenzi*

CONSIDERABLE INTEREST has been aroused by the design of the steam generating units, recently installed in the Duluth (Minn.) Steam Electric Station of the Minnesota Power & Light Co. and in the Boncar (W. Va.) plant of the West Virginia Hydro-Electric Co. In both of these installations, the steam plant serves as a "stand-by" to hydro stations and it became necessary to make a careful and detailed economic study to determine on the optimum design.

The principal interesting feature of these two installations is that the boiler unit selected is of the single pass, sectional-header design. In each case, the boiler is 40 tubes high. This height is sufficient to eliminate the use of either an economizer or air preheater, yet the efficiency of the unit is higher than obtained with the conventional three-pass boiler. The draft loss is sufficiently low so that it is not necessary to provide induced draft fans. The actual height of the boiler itself is approximately 13 ft. greater than a 14 row high three pass boiler.

At Duluth the unit is designed for a continuous load of 300,000 lb. per hr. and a 4-hr. peak load of 325,000 lb. of steam per hour, when burning Pittsburgh and Allegheny coals. The operating pressure is 415 lb. per sq. in. with a total steam temperature of 760 deg. F. This boiler contains 36,550 sq. ft. of heating surface, arranged in 38 sections wide, 40 rows high and made up to 4-in. tubes 21 ft. long. This tube surface is divided into three definite banks or decks. The lower deck is made up of four full rows of tubes. The superheater, which is made up of 2-in. plain tubes, arranged 74 rows wide and 11 rows high, contains 8300 sq. ft. of gas touched surface. This superheater is located in the space directly above the lower deck of the boiler. The upper section of the unit is made up of two banks of tubes. The lower one is 20 rows high, while the upper one is 16 rows high. Three rows of horizontal circulators serve to connect the uptake headers to the boiler drum. This drum is of riveted construction and is 60 in. internal diameter, approximately 30 ft. long.

A furnace for pulverized fuel firing is provided with the pulverized fuel fired through six forced draft, horizontally fired, turbulent burners. These burners are arranged in two rows of three each. Provision is made for burning coke oven gas, in these same burners, when available. The four furnace walls are of the C-E water cooled construction, in which bare tubes are exposed to the full furnace temperature. This method of cooling is extremely effective, because of the high rate of heat absorption, by radiation, from the furnace gases. A bottom screen, for shielding the ash pit and preventing the formation of slag, consists of a double row of 4-in. tubes, spaced on relatively wide centers, and connected in to the rear wall circuit. The total radiant heat absorbing surface, in the walls, is 4260 sq. ft. and the effective furnace volume is 18,500 cu. ft.

Boncar Boilers

At Boncar, the unit installed is similar in design to the one in Duluth but is only 33 sections wide with 31,885 sq. ft. of heating surface. The corresponding furnace width is 19 ft. 6 in. instead of 21 ft. 5 in. as at Duluth. The furnace is fully water-cooled and contains 4200 sq. ft. of direct radiant heat absorbing surface. The maximum capacity of the unit is 325,000 lb. of steam per hr. and the operating pressure is 425 lb. with a total steam temperature of 750 deg. F.

Like the Duluth unit, it is fired with pulverized fuel although the method of firing is somewhat different. Eight tangential burners per furnace are provided, and these burners are located in the four corners of the furnace. The streams of coal and air issuing from the burners are directed along tangents, to an imaginary circle, lying in a horizontal plane, and located in the center of the furnace. This method of mixing the coal and air produces intense turbulence and speeds the combustion process, therefore it is possible to reduce the

*Combustion Engineering Corporation, New York, N. Y.

required furnace volume and operate at higher rates of heat liberation. The volume provided at Boncar is 14,500 cu. ft.

Units referred to in the foregoing description are well illustrated in Fig. 1. The question is now immediately raised as to how an installation of this type can be justified, in competition with the conventional three pass boiler, equipped with an air preheater. As previously stated, the units serve as stand-by to water

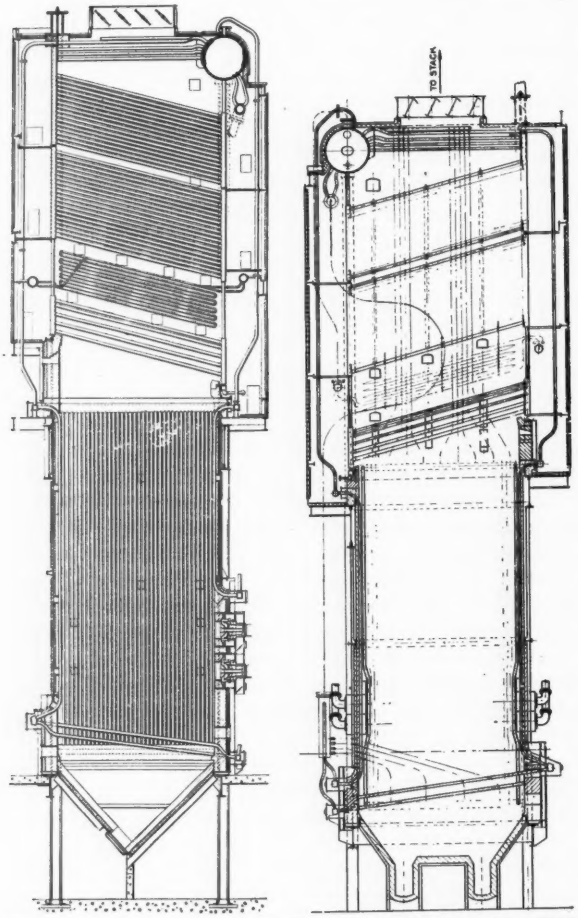


FIG. 1. (LEFT) SECTION OF THE DULUTH BOILER OF THE MINNESOTA POWER & LIGHT CO. (RIGHT) SECTION OF THE BONCAR BOILER OF THE WEST VIRGINIA HYDRO-ELECTRIC CO.

power. The yearly load factor may vary from 2 per cent to 15 per cent or more. The steam units, when operating, will carry a constant load. The variations and peak loads are taken by the water power.

Operating Advantages

In order to justify the selection of the single-pass unit, it is necessary to make a comparative analysis with a suitable three-pass boiler, operating under the same conditions. Assume that the comparison is to be made on the basis of the Boncar unit. In order to meet the operating conditions, a three-pass boiler, having a heating surface of 20,150 sq. ft., is selected with a furnace width of 25 ft. A fully water-cooled furnace is provided, having 4350 sq. ft. of heat absorbing surface. In addition to the foregoing, air heating surface of 39,340 sq. ft. is also provided.

In Fig. 2 is shown a curve, giving some of the principal performance characteristics and operating efficiencies of the two types of units. In making a heat balance analysis, identical furnace CO_2, carbon loss, radiation and unaccounted for losses, are used to arrive at the comparative efficiencies of the units. From this analysis, we find a definite advantage, due to higher efficiency, in the three-pass unit. On the other hand, because of the difference in draft losses, it is possible to operate the single-pass unit on natural draft, while the three-pass unit requires an induced draft fan. To supply this additional draft, electrical energy is required, therefore it is necessary to charge the cost of the required additional installed capacity against the high draft loss unit. In addition to the fixed charges, the fuel cost for developing this auxiliary electrical energy must be charged against the three-pass unit. Furthermore, induced draft fans are subject to relatively high maintenance charges and these must also be accounted for. Both units must be provided with stacks, and the height and cost of these is greater in the case of the single pass unit. One of the operating characteristics, of the single-pass unit is the low draft loss. This is due to three factors: relatively low mass flow through the unit; the absence of baffles and turns which cause eddy currents; the so-called "stack effect," because of the height of the unit.

Both types of units are equipped with forced draft fans. However, more power is required where an air preheater is used, because of the added resistance in the air circuit. Here again we must account for the cost of additional installed capacity, as well as the cost of fuel, to develop the required excess energy. Various studies have been made to determine the relative building volumes required to house these two types of units. Invariably, there has been an advantage in favor of the single-pass unit. The excess building volume required must therefore be charged against the three-pass unit.

With its larger superheater (because of lower mass flow), the single-pass boiler is considerably higher in cost than the three-pass boiler, with its superheater; however, this difference is offset by the cost of the air preheater and induced draft fan, thus it is possible to say that the first cost of the steam generating equipment is practically the same in the two cases.

Decision in favor of the single-pass unit is then based on the difference in operation and maintenance costs, as well as on the saving in building volume. Units of this type are of relatively simple construction, because of the minimum amount of auxiliary equipment; because of their simplicity, they have an extremely high availability factor.

Best for Low Load Factors

In the operation of the single-pass units, it has invariably been found that the exit gas temperatures actually obtained were considerably less than those predicted. The explanation of this is that the gases, in passing through the unit, are constantly in contact with clean heat absorbing surfaces. The dust and soot accumulations occur on the upper side of the tube while the gases scrub over the lower side of the tube. This is true in the three-pass boiler, in only the first and third passes. The effectiveness of the second pass, which may contain 25 to 30 per cent of the tube heating surface,

is dependent on the thickness of the dust accumulation, on the upper side of the tubes. Frequent blowing of the soot and dust will serve to keep the entire unit more fully effective. These soot blowers, however, may be omitted from the single-pass type of unit. It is necessary only to provide access for hand lancing the tubes, at infrequent intervals. The elimination of soot blowers means a material saving in the first cost of the unit and it also means lower operating and maintenance costs.

Various analyses indicate that the single-pass boiler is particularly suited for low load factor units. The sizes most easily justified lie in the range from 200,000 to 400,000 lb. per hr. capacity. At capacities below 200,000 lb. per hr., the design is not economical, because of the high ratio of the drum and header costs, to tube surface cost. Above 400,000 lb. per hr., the size of the

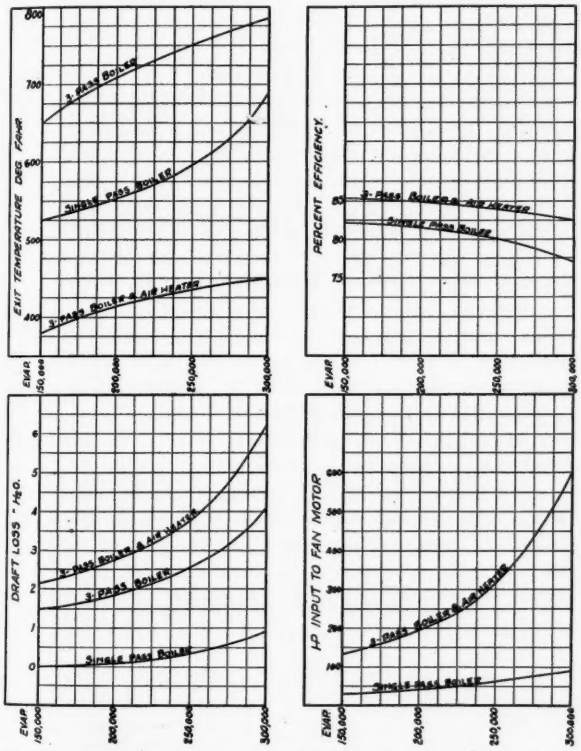


FIG. 2. COMPARATIVE PERFORMANCE AND EFFICIENCY CURVES OF SINGLE AND THREE-PASS BOILERS

unit is limited by the length that it is possible to manufacture the drums, and also by the amount of steam that can safely be generated by each section in the boiler. Of course, fuel costs also play an important part in the selection of these units. Relatively low cost fuels usually indicate that it is desirable to investigate the possibility of installing units of this type. Because it is difficult to secure sufficient grate area for equivalent capacity, the unit is not particularly well suited to stoker firing but pulverized fuel, gas and oil are most ideally suited to its requirements.

In conclusion, it may be pointed out that actual installations and their operation, indicate that all of the foregoing claims for the single-pass unit have been met. In fact, the performance of these units has exceeded the guarantee figures by comfortable margins. Because of simplicity and the reduction of auxiliary equipment to a minimum, units of this type will find application in many future installations, particularly those having low load factors. The high availability factor, because of design simplicity, gives assurance that the unit, when once placed in service, will continue to function with the minimum amount of outage due to maintenance requirements.

International Congress for Testing Materials

FIRST INTERNATIONAL CONGRESS of the New International Association for the Testing of Materials will be held this year from September 6 to 12 in Zurich, Switzerland, in the buildings of the Swiss Federal Polytechnicum. The Association consists of individuals and companies in the various countries. In the United States, the national association through which contacts are established is the American Society for Testing Materials and many of its members belong to the international body.

The technical program has been divided into four groups indicated:

Group A—Metals; Group B—Non-Metallic Inorganic Materials; Group C—Organic Materials; Group D—Questions of General Importance.

Americans, all members of the American Society for Testing Materials, will have a prominent part in the program. The following authors will give the papers designated:

F. F. Lucas, Metallurgist, Bell Telephone Laboratories, New York City, "Advances in Microscopy."

D. J. McAdam, Jr., Metallurgist, U. S. Naval Engineering Experiment Station Annapolis, "Stress Corrosion of Metals."

W. A. Slater, Research Professor of Engineering Materials, Lehigh University, "Designing Concrete for High Strength, Low Permeability and Low Shrinkage."

F. E. Richart, Associate Professor of Mechanics, University of Illinois, "Stresses and Strains in Reinforced Concrete Columns."

W. A. Selvig, Chemical Engineer, U. S. Bureau of Mines, Pittsburgh, "Sampling Coal."

Prevost Hubbard, Chemical Engineer, The Asphalt Institute, New York City, and C. S. Reeve, Chief Chemist, The Barrett Co., New York City, "Tests for Bituminous Materials."

L. T. Work, Assistant Professor, Chemical Engineering, Columbia University, "Present Status of Particle Size Measurement."

H. F. Moore, Professor of Engineering Materials, University of Illinois, "Calibration of Testing Machines."

F. B. Seely, Professor of Mechanics, University of Illinois, "Ideal and Practical (Test) Relations Between Elasticity and Plasticity, Tenacity and Brittleness."

W. H. Fulweiler, the A.S.T.M. representative on the Permanent Committee which governs the International Association, is Chemical Engineer of the United Gas Improvement Co., Philadelphia. Further details may be procured from him or C. L. Warwick, Secretary-Treasurer, American Society for Testing Materials, 1815 Spruce St., Philadelphia, Pa.

Practice, Operation and Control *of* REHEAT BOILERS

DATA AND BOILER DESIGN OF THE SCORE OF INDUSTRIAL AND CENTRAL STATION 600 TO 1800 LB. PRESSURE PLANTS USING REHEAT

ABOUT A SCORE of reheat stations have been built or are under way in this country and significant data on those constructed are given in the tabulation. References to pages refer to past issues of Power Plant Engineering in which the plants were described while the reference to the review number refers to the Annual Review Number of the magazine in which data on different parts of the plant are tabulated.

Of the 600-lb. group, Twin Branch, Philo, Crawford and Columbia were put in service at about the same time and used a special reheat boiler of the type shown by Fig. 1. High pressure steam was generated in standard boilers and after partial expansion in the high pressure turbine cylinder was resuperheated in the convection coils of the special reheat boiler. The lower part of the boiler and superheater made high-pressure steam and served only as a screen to reduce the temperature of the combustion gases to about 1200 deg. F. before they swept over the reheater. The rate of firing the reheat boiler gave control over the reheat temperature.

Stanton, Powerton, Edgar and later Gilbert used adaptations of this type but Edgar and Holland eliminated the standard boiler. As the rate of firing in this case depends upon the steam demand, some arrangement is necessary to control the reheat temperature. Edgar used a movable baffle as shown in Fig. 2 while Gilbert used a steam reheater in series with the convection coils[1] shown in Fig. 4.

While high pressure developments were under way, reheat practice was affected somewhat by the steam reheater installation at Crawford and State Line. In spite of satisfactory operation reported for reheat boilers, complications of control equipment and piping made changes desirable and steam reheaters were introduced in the two stations mentioned.

Edgar was the first of the 1200—1400-lb. stations, but was closely followed by Lakeside, which broke away from previous reheat practice and installed a bent tube boiler with a radiant superheater and reheater. The latest unit of this type, shown in Fig. 6, uses a radiant superheater made of 2-in. O.D. No. 1 gage, chrome vanadium steel in the side walls and a convection reheater located in the second pass of the boiler. At Northeast a radiant reheater was also adopted.

Like Edgar, the 1200-lb. equipment is superimposed on a 300-lb. station and the high pressure turbines discharge at constant pressure through the reheater to the low-pressure mains to be used in any of the low pressure turbines. Each high-pressure turbine receives

[1]See Fig. 5, page 698, July 1 issue

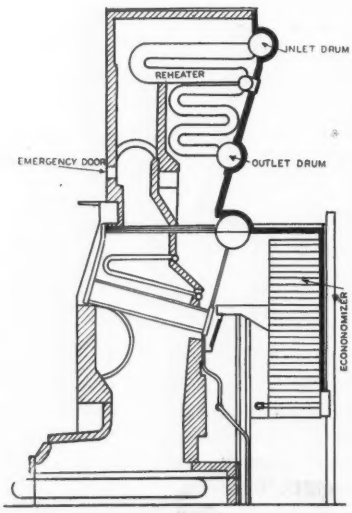


FIG. 1. ORIGINAL REHEAT BOILER AT CRAWFORD

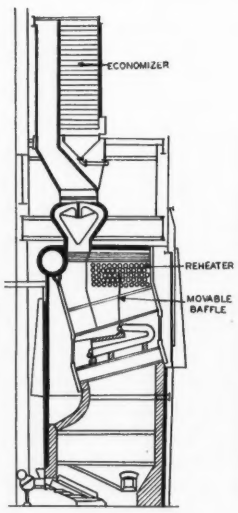


FIG. 2. REHEAT BOILER AT EDGAR

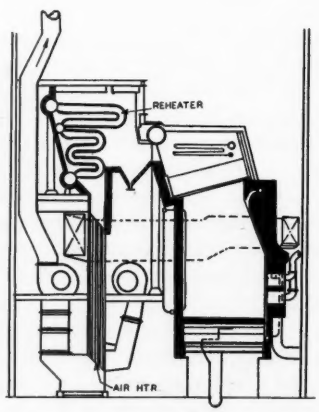


FIG. 3. REHEAT BOILER AS USED AT POWERTON

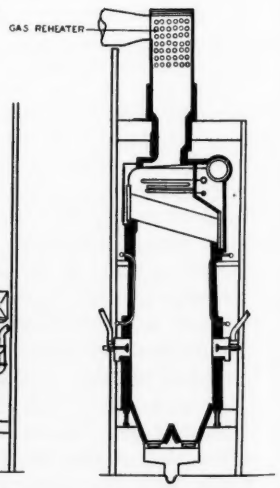
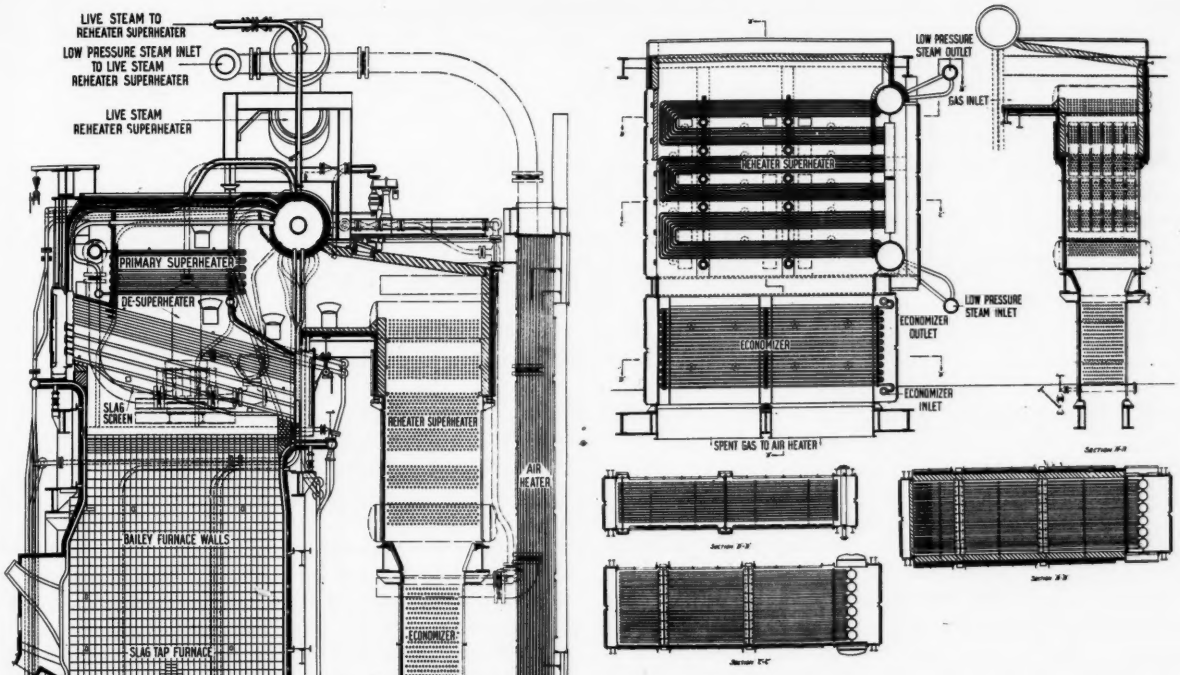


FIG. 4. RECENT DESIGN AT GILBERT



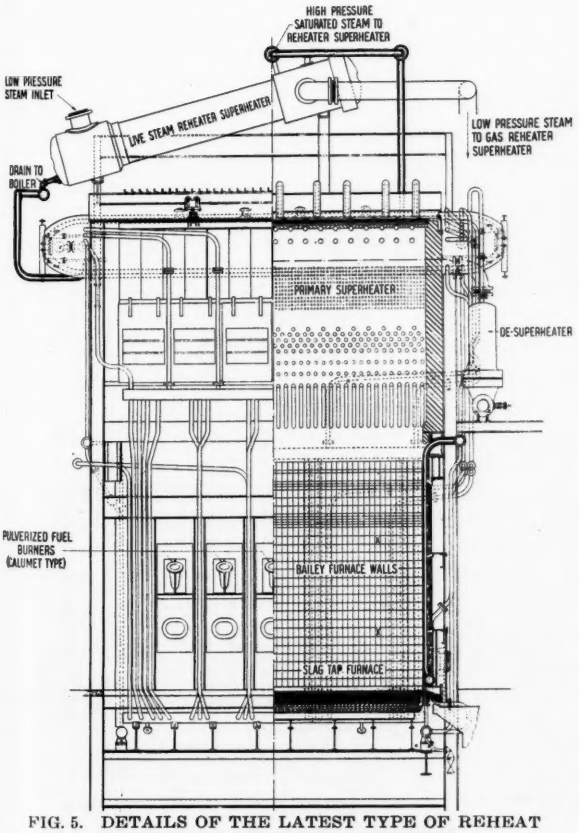


FIG. 5. DETAILS OF THE LATEST TYPE OF REHEAT BOILER AS USED AT SOUTH AMBOY

steam from a single high-pressure boiler and the exhaust passes through the reheater of the same boiler. Exhausting at constant pressure, the heat in the exhaust steam, consequently its temperature, increases at the lower loads. The characteristic of the convection superheater to give lower superheat at low loads balances the increased temperature of the exhaust and so gives a practically uniform reheat temperature at all loads.

In a plant with a multi-valve, multi-expansion turbine operating at a variable crossover or reheat pressure, conditions would be different. For such an installation a combination superheater and all radiant reheater would be best. A flat primary superheat and uniform reheat temperature curve could be obtained from overload down to quarter load automatically without regulation.

Following the original 1200—1400-lb. installations, developments in this field were rapid with Gilbert, Deepwater, Station A and South Amboy planned and completed at about the same time. The 600—800-lb. range passed entirely out of the picture, even State Line finding it advisable to change the second and third units to 1400-lb. Studies indicate[2] that when considering total production costs, 550-lb. reheat is less economical than a 400-lb. no reheat or 1200-lb. reheat plant. Choice of the last two is determined by fuel costs and load conditions.

Of the four new 1400-lb. stations mentioned, Gilbert abandoned the standard boiler but used an adaptation of the previously used convection reheat coils in series with a steam reheater to give reheat temperature control. Deepwater, Station A and South Amboy used a new and radically different construction that, with the Lakeside type, promises to become standard practice. These units, shown in Fig. 5, are in effect the Calumet type boiler with the convection reheat elements

[2]See Holland Station Mar. 1, 1929, page 282.

DATA ON REHEAT STATIONS COMPLETED OR UNDER CONSTRUCTION

STATION	Plant Description Issue	Page	Annual Review Issue	Steam Conditions Initial Pres. per sq. in.	Initial Temp. °F	Reheat Pres. per sq. in.	Reheat Temp. °F	Boilers per turbine unit Std.	Boilers per turbine unit Reheat	Reheat Equipment
			600—800 lb.							
Philo	June 1, 1925	570	Jan. 1, 1927	600	725	150	725	3	1	Convection
	Sept. 1, 1930	965	Dec. 15, 1928	750	750	132	750	4	2	Convection
Columbia	Nov. 1, 1925	1120	Jan. 1, 1927	600	750	115	725	3	1	Convection
Crawford	July 1, 1925	676	Jan. 1, 1927	650	750	120	725	4	1	Convection
	Oct. 15, 1928	1077	Dec. 15, 1928	650	750	61	500	6	0	Steam
Twin Branch	Jan. 15, 1926	118		650	725	150	725	3	1	Convection
Stanton	Sept. 1, 1927	916	Dec. 15, 1927	625	750	160	725	3	1	Convection
Powerton	Nov. 15, 1928	1198		650	750	160	725	2	1	Convection
State Line	June 15, 1928	685								
	Nov. 1, 1929	1171	Dec. 15, 1929	800	730	110	500	4	0	Steam
			1200—1400—1800 lb.							
Edgar	June 1, 1927	605								
	July 15, 1928	785	Dec. 15, 1928	1400	730	350	750	0	2	Convection
Lakeside	Feb. 15, 1928	229	Dec. 15, 1927	1400	725	300	725	0	1	Radiant
Northeast	Feb. 15, 1929	259		1400	725	290	725	0	2	Radiant
Gilbert	Mar. 1, 1929	282	Dec. 15, 1929	1400	750	415	750	0	2	Convection
Deepwater	Nov. 15, 1929	1204	Dec. 15, 1929	1400	725	400	750	1	1	Convection
Station A	June 15, 1930	664	Dec. 15, 1929	1400	750	390	750	1	1	Steam and Conv.
So. Amboy	July 15, 1930	788	Dec. 15, 1930	1400	750	350	750	0	1	Steam and Conv.
River Rouge	Mar. 15, 1931	354		1400	725	80	550	2	0	Steam
Deepwater (Tex.)	Future		Dec. 15, 1930	1400	820	350	700	2	0	Steam
Concepcion Rd.	Future		Dec. 15, 1930	1400	725	200	575	1	0	Steam
Carey	Future			1800	850	300	600	1	0	Steam

located where the steaming economizer would normally be placed; otherwise the boiler is the same as a standard boiler. This boiler arrangement may be used with a steam reheater of any type, an air preheater, economizer or with any combination as the heat balance of the station dictates. So far only convection superheat and reheat elements have been used with this type of boiler, although radiant elements could be added if desired just as in the bent tube type.

Tabulated data indicate developments in reheat practice were largely a reflection of the increased boiler sizes of the industry as a whole. Stations are arranged chronologically according to the published descriptions which does not necessarily indicate the order in which the stations were built, although it gives a good indication. Looking down the column showing the number of boilers per turbine unit, the rapid decrease in the number of boilers per turbine is evident. Recent stations have but one or at most two boilers, depending upon the arrangement selected.

Of the new stations the use of one or two boilers appears to be largely a matter of steam demand. So far, recent reheat central stations have been content with 25,000 or 50,000 kw. turbines, supplying the first with a single and the second with two boilers corresponding to an approximate boiler output of 250,000 lb. of

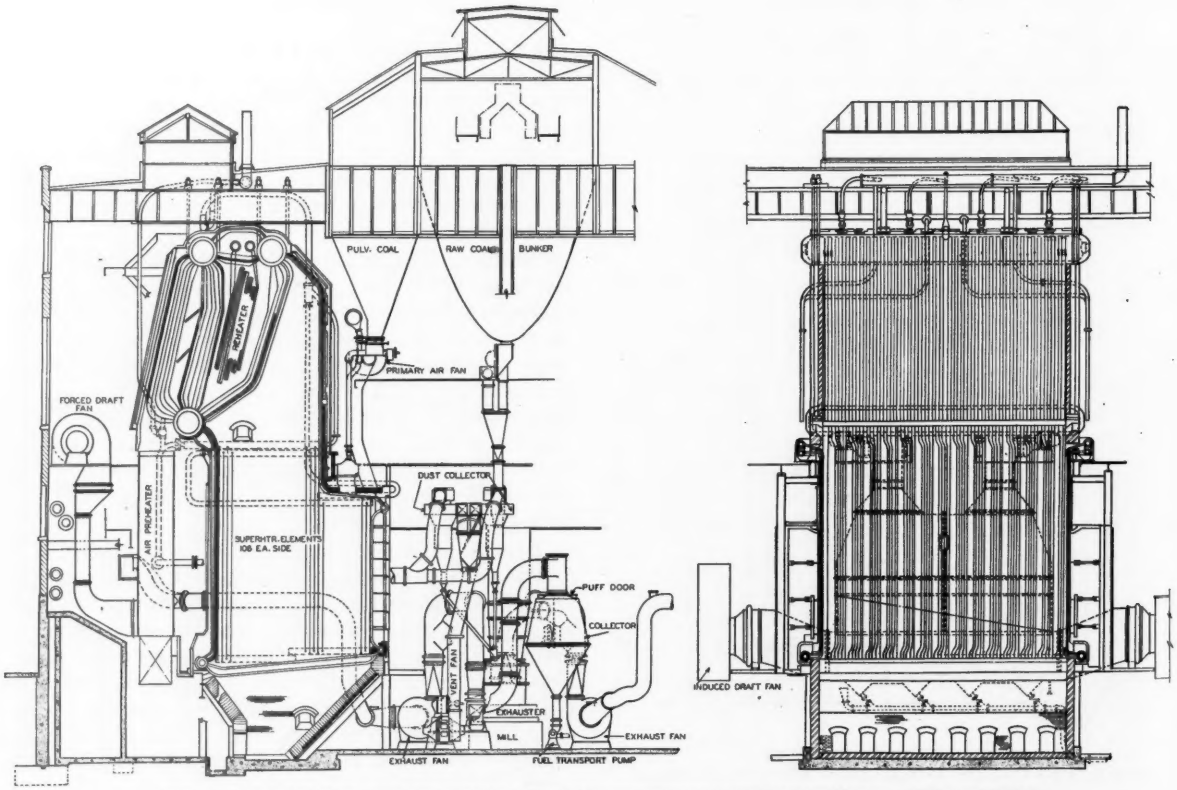


FIG. 6. BENT TUBE BOILER WITH RADIANT SUPERHEATER DEVELOPED AT LAKESIDE

steam per hour. The Ford plant, however, with a steam reheater makes use of two 700,000-lb. per hr. boilers to supply the 110,000-kw. steeple compound unit.

Boiler size limitations are gradually increasing, however, so that it is not unreasonable to expect that reheat boilers of from three-quarters to a million pounds of steam an hour can be built if local conditions in some section of the country would justify reheat turbine units of such a size.

With the present situation regarding binary vapor cycles and very high temperatures, it is impossible to predict future trends but it seems that the 1400-lb. plant is firmly established and that the compact boiler designs of Figs. 5 and 6 will become standard practice.

Flue Gas Analyses Reveal Furnace Operation

USE OF CHART GIVES DIRECT MANY COMBUSTION RATIOS USED IN COMPARING FURNACE PERFORMANCE. BY RICHARD BROWN*

COMMERCIAL FUELS in most cases are composed principally of hydrogen and carbon. Notable exceptions are blast furnace and producer gas, which contain high percentages of nitrogen and carbon dioxide and accordingly do not permit of the following analysis.

Fuels which do lend themselves to this analysis are, carbon, coke, coal, oil, natural gas and hydrogen. The hydrogen-carbon ratios of these fuels are as follows:

Fuel	Hydrogen-Carbon Ratio = R
Carbon	0.00
Anthracite Coal	0.02-0.03
Coke	0.02-0.03
Bituminous Coal	0.04-0.06
Acetylene	0.083
Oil	0.10-0.20
Ethane	0.25
Methane	0.33
Natural Gas	0.28-0.33
Hydrogen	Infinity

Relative quantities of carbon dioxide, nitrogen and oxygen in the products of combustion are definitely related to the relative quantities of hydrogen and carbon in the fuel burned. For example, when carbon is burned with air the total of CO_2 plus O_2 is always 20.9 per cent regardless of the quantity of air used for combustion. When hydrogen is burned with air, there is no CO_2 in the products of combustion, and the O_2 varies from zero to 20.9 per cent as the excess air percentage varies from zero to infinity.

When the ultimate analysis of a fuel is known the hydrogen-carbon ratio may be obtained from the relation

$$R = (H - 0/8) \div C$$

Where H, O and C are percentages of hydrogen, oxygen and carbon. For all practical purposes R may be selected from the table given above.

Assuming that any fuel under consideration is composed entirely of hydrogen and carbon and that air is 20.9 per cent O_2 and 79.1 per cent N_2 by volume, the following formulas may be derived:

Let C = Lb. of carbon per pound of fuel
H = Lb. of hydrogen per pound of fuel

Then (1.) $R = H \div C$

(2.) $C = 1 \div (1 + R)$

(3.) $H = R \div (1 + R)$

(4.) B.t.u. $= (14{,}600 + 62{,}000R) \div (1 + R)$ B.t.u. per pound of fuel

(5.) $W_a = 11.52\ (1 + 3R)\ (1 + A_e) \div (1.46 + 6.2R)$
= Pounds of air used per 10,000 B.t.u.

(6.) $W_g = [1 + R + 11.52\ (1 + 3R)\ (1 + A_e)] \div (1.46 + 6.2R)$
= Pounds of gas per 10,000 B.t.u.

It may also be shown that when combustion is complete the following formulas hold true:

(7.) $A_e = (0.791\ O_2) \div (20.9 - 0.209\ CO_2 - O_2)$
= Per cent excess air.

Where O_2 and CO_2 are percentages by volume

(8.) $A_e = [20.9 - CO_2\ (1 + 2.373R)] \div CO_2\ (1 + 3R)$

(9.) $R = (20.9 - O_2 - CO_2) \div 2.373\ CO_2$

(10.) $V = 0.292T\ [1 + 3.64R + A_e\ (1 + 3R) + W\ (0.203 + 0.086R)] \div (1.46 + 6.2R)$

Where T = Absolute temperature, deg. F.
W = Pounds of water in fuel and air per 10,000 B.t.u. in fuel
V = Cubic feet of gas per 10,000 B.t.u. in fuel

(11.) $P = (18.4R + 3W + 12.7WR) \div [1 + 3.64R + A_e\ (1 + 3R) + W\ (0.203 + 0.861R)]$
= Partial pressure of water vapor in products of combustion expressed in pounds per square inch absolute.

(12.) $L_g = [305 + 1111R + A_e\ (281 + 843R)] \div (146 + 620R)$
= Per cent gas loss per 100-deg. rise of the products of combustion.

(13.) $L_h = 953R \div (14.6 + 62R)$ = Latent heat loss due to combustion of hydrogen, per cent.

(14.) Drop/Rise $= [281 + 843R + A_e\ (281 + 843R)] \div [305 + 1111R + A_e\ (281 + 843R)]$
= Ratio of temperature drop to temperature rise in an air heater heating 100 per cent of the air used for combustion.

In order to facilitate combustion calculations, chart "D" has been made. On the chart 10 of the factors obtainable from the formulas given above are in alinement. To use the chart, a straight line is passed across it intersecting the various scales at simultaneous values of the several factors under consideration. For example, if from a volumetric gas analysis 13 per cent CO_2 and 5 per cent O_2 are obtained, we would determine from the chart that R = 0.1. If bituminous coal were being burned, it would be obvious that the gas analysis was wrong. In other words, the gas analysis would not fit

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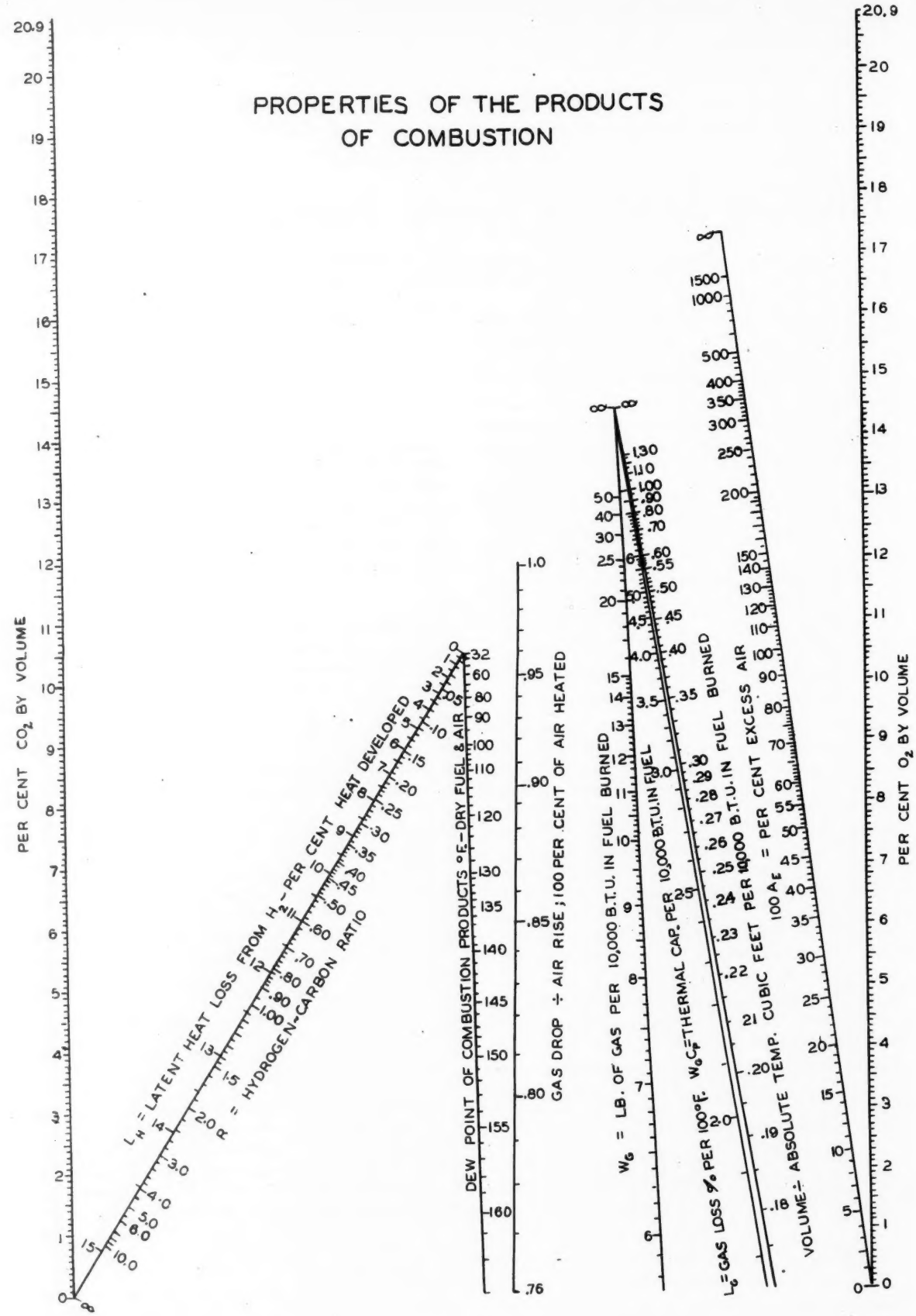

PROPERTIES OF THE PRODUCTS OF COMBUSTION
PER CENT CO_2 BY VOLUME
L_H = LATENT HEAT LOSS FROM H_2 - PER CENT HEAT DEVELOPED
R = HYDROGEN-CARBON RATIO
DEW POINT OF COMBUSTION PRODUCTS °F.-DRY FUEL & AIR
GAS DROP ÷ AIR RISE; 100 PER CENT OF AIR HEATED
W_G = LB. OF GAS PER 10,000 B.T.U. IN FUEL BURNED
L_G = GAS LOSS % PER 100°F. $W_G C_p$ = THERMAL CAP. PER 10,000 B.T.U. IN FUEL
VOLUME ÷ ABSOLUTE TEMP. CUBIC FEET PER 10000 B.T.U. IN FUEL BURNED
100 A_E = PER CENT EXCESS AIR
PER CENT O_2 BY VOLUME

the fuel which has an R value between 0.04 and 0.06.

The following problem is taken to illustrate the use of the chart.

A steam generating unit delivers 225,000 lb. of steam per hour when burning 22,500 lb. of bituminous coal having a heating value of 14,000 B.t.u. per pound. Temperature of gas leaving air heater and entering induced draft fan is 350 deg. F. Temperature of air is 70 deg. F. $CO_2 = 14.4$ per cent $O_2 = 4.9$ per cent by volume. Unaccounted for losses = 4 per cent.

By passing a straight line across the chart intersecting the oxygen scale at 4.9 and the carbon dioxide scale at 14.4, the following values are determined.

$A_e = 0.3$ or 30 per cent.
$V/T = 0.251$ cu. ft. per 10,000 B.t.u. per deg. F. absolute.
$L_g = 2.59$ per cent per 100 deg. rise.
$W_g = 10.3$ lb. of gas per 10,000 B.t.u.
Drop/Rise = 0.92
Dew Point = 85 deg. F.
$R = 0.05$
$L_h = 2.7$ per cent.

From these factors, the following calculations may be made:

Over all efficiency of unit

Latent heat loss, L_h	=	2.7 Per cent
Gas Loss, L_g (350—70) 2.59/100	=	7.25 Per cent
Unaccounted for losses	=	4.00 Per cent
Total losses	=	13.95 Per cent
Efficiency	=	86.05 Per cent
		By difference.

Volume of gas to induced draft fan.

$V/T = 0.251$ $T = 460 + 350 = 810$ deg. F. absolute.

Cubic feet of gas per minute =

$0.251 \times 810 \times 1.4 \times 22{,}500/60 = 106{,}900$ c.f.m.

Density of gas =

$W_g \div V = 10.3 \div 0.251 \times 810 = 0.0507$ lb. per cu. ft.

Specific heat of gas =

$W_g C_p \div W_g = 2.59 \div 10.3 = 0.252$

Dew Point

A dew point of 85 deg. F. would be obtained from burning dry fuel of $R = 0.05$ with dry air. If, however, we assume, for example, that there is 0.1 lb. of water in fuel and air per 10,000 B.t.u. in fuel, the dew point would be increased approximately 10 deg. F. The dew point under these conditions can be determined from formula 11 above. Working out the value of P when $R = 0.05$, $A_e = 0.3$ and $W = 0.1$ it is found that $P = 0.829$ lb. per sq. in. absolute. This pressure corresponds to 96 deg. F., which is the dew point under the assumed conditions. Values of the dew point on the chart are for conditions of dry fuel and air, but will be found to be only slightly lower than those determined from formula 11 except under extreme conditions.

Ratio of Gas Drop to Air Rise

If in the original problem only 90 per cent of the air for combustion were heated in the air heater and the gas drop were found to be 250 deg. F., then the air rise would be $250 \times 0.9 \div 0.92 = 244$ deg. F.

The chart is useful in comparing efficiencies attainable with different fuels. The change in efficiency is due principally to the variation in latent heat loss and can be determined from the L_h and L_g scales. For example, assume that the stack temperature is 350 deg. F. and air temperature is 70 deg. F. Also that coal of $R = 0.05$ is burned with 30 per cent excess air, and natural gas of $R = 0.3$ is burned with 10 per cent excess air. For the coal, a stack loss of 10 per cent would be obtained and, for the gas, a stack loss of 14.5 per cent would be obtained, giving the coal an advantage over the gas of 4.5 per cent in spite of the fact that considerably less air was used in burning the gas.

Maximum percentage of carbon dioxide may be read directly from the chart by passing a line through zero oxygen and the desired value of R.

It will be found that calculations made from this chart will check those made by conventional methods.

German Turbine Tests

TEST RESULTS for a 16,100-kw., 3000-r.p.m. single-cylinder turbine at the Fortuna power station of the Rhenish Electricity Works Co., Cologne, have been reported by the turbine manufacturers, Siemans-Schuckert. During the test the cooling water was about 80 deg. F., colder than guarantee value, resulting in a high vacuum which increased the exit loss. In spite of this, test results exceed the guarantee figure by a considerable margin.

TEST RESULTS OF TURBINE NO. 2 AT FORTUNA POWER STATION, COLOGNE

Generator output, kw.	16,040	13,992	12,197
Generator Eff., %	94.7	94.4	94.0
Throttle pressure, lb., abs.	194.5	196	195
Throttle temperature, deg. F.	664	660	654
Vacuum, in. Hg. (approx.)	27	28	27.8
Generator Eff., %	94.7	94.4	94.0
Steam consumption, lb. per kw-hr. (at coupling)	10.73	10.05	10.15
Adiabatic heat drop B.t.u. per lb.	384	405	400
Rankine Ratio referred to turbine coupling	82.7	84.0	84.0

PRACTICALLY EVERY new development of furnace construction calls for some special refractory shapes. It is obvious that these specials should be reduced to the minimum both to avoid excessive cost and maintenance trouble. While there can be no standardization of these special shapes, there are some general rules that apply and which will be of assistance to both manufacturer and user.

The important thing is to remember that the brick must be molded and that the design best adapted to manufacturing will give the best service. This is true, because a mold difficult to fill properly is likely to have defects, such as, folds, sand cracks, or spongy corners, and that complicated shapes may set up severe internal strains or have corners that protrude and are easily chipped off both in service and handling.

Again, under severe conditions, small units give better service than large ones because internal strains set up by rapid cooling or heating are roughly proportional to the size of the individual piece. If the brick is to fit around a casting, it is best to send an actual casting sample if available. Shrinkage also causes difficulty at times and it is best to give the permissible variation in dimensions and indicate the faces which should be regular and true. Most shapes can be molded in two or more ways and if the mold makers know beforehand, they can usually make the mold so that the slight irregularities which almost always appear on one face of a hand molded brick can be made so that the irregularities do not cause trouble in laying up the finished work.

Quick Start for Turbine Units*

IT IS WELL recognized that running of spare units on a system is inefficient but, unless quick starting can be effected, it is essential where emergency peaks are possible.

For present conditions, a two-shaft turbine unit of 70,000 kw. capacity at 0.8 power factor, speed 1500 r.p.m. steam at 447 lb. and 752 deg. F. will come safely to 30 per cent of normal speed in 1 hr. from a cold start and to full speed in 1½ hr. It can be loaded 1¾ to 2 hr. after starting but load should be built up slowly as the critical state of maximum blade play, shaft expansion and housing expansion comes some 4 to 5 hr. after the start.

Too sudden starting and loading may result in rubbing of wheel and guide blades with wear or stripping. after a short shut-down, say 2 hr., start and loading can be quick but, if shut-down is longer, 24 hr. should elapse before starting again because of distortion of the low-pressure rotor from uneven cooling.

On a single-shaft unit of 37,500 kw. capacity at 0.8 power factor, 1500 r.p.m., steam at 198 lb. and 707 deg. F., with 2-stage bleeding, start could be made in ¾ hr. to full speed and in 1½ hr. to full load after 10 hr. shut-down. Critical maximum expansion comes in 2¼ to 3 hr. but the increase was too small to cause trouble. In fact, full load was applied within a few minutes of paralleling without harmful results.

For a three-cylinder machine of 20,000 kw. at 3000 r.p.m., steam at 174 lb. and 662 deg. F., normal starting was in 30 min. or for emergencies in 13 min. If all harmful heat and mechanical stresses could be eliminated, starting would be limited only by the inertia of revolving parts to from 10 to 15 sec. To effect this elimination becomes a constructional and operating problem.

For quick work a minimum of controls, valves and drains, placed close to the turbine and operated from one position are essential. In contrast, it is to be noted that one 16,000-kw. unit for 1500 r.p.m. had 50 valves, 30 of which must be opened and 12 closed again while starting up. On another unit of 30,000 kw. at 3000 r.p.m., 42 valves are to be opened and 26 to be reclosed while a 37,500-kw. unit at 1500 r.p.m. has 52 valves to be opened and 27 to be reclosed. Other valves not used in starting, need inspection and some adjustment while running. Obviously, greater simplicity would make for speed and reliability in operation.

Time is needed to start condensers, as vacuum of 12 in. should be obtained before turning steam into the turbine, requiring 5 to 10 min. Bringing in the condenser can be accelerated by having all auxiliaries on one shaft and using large vacuum pumps for quick action, also large control valves mechanically operated.

In design, parts requiring warming should be as small as possible and of shape to heat evenly, with minimum distortion. Expansion of shaft and housing should be in the same direction and ribs avoided, if possible. Distortion is especially liable at the high-pressure steam inlet and at outlets for bleeder stages.

Drainage connections should be few, simple and flexible.

As the shaft expands sooner than the housing, axial clearance must allow for it in blades and stuffing-boxes. Built-up construction and small shafts tend to ensure even, rapid heating but construction must be rigid against loosening or distortion.

Warming by live steam with the rotor at rest is not permissible, also cooling down must be even, though barring over every few minutes after shutting down should be avoidable by proper design.

From the standpoint of readiness to serve, the single shaft machine is better than multi-shaft as steam sufficient to turn over the high-pressure rotor will not rotate the low-pressure rotors and warming them with live steam is undesirable. Connecting the generators of multi-shaft machines electrically will rotate the low-pressure units but this increases the time required for starting. In the single-shaft arrangement, the high-pressure rotor turns the low-pressure mechanically.

So far, time required to start the turbine end has been such that inertia stresses in the generator have needed no consideration. In large machines, axial movement between iron and windings may be several hundredths of an inch, which can be cared for by arranging for the windings to slide in the rotor and by elastic insulation and flexible connections in the stator between bars and end windings.

With present construction, it should be assumed that for units of 20,000 to 40,000 kw., 25 to 40 min. are needed from start to full load. Shorter emergency starts involve risk and even more time is desirable when possible.

*From a paper by Dr. A. Peucker before the World Power Conference.

High Tides of Bay of Fundy May Be Harnessed for Power

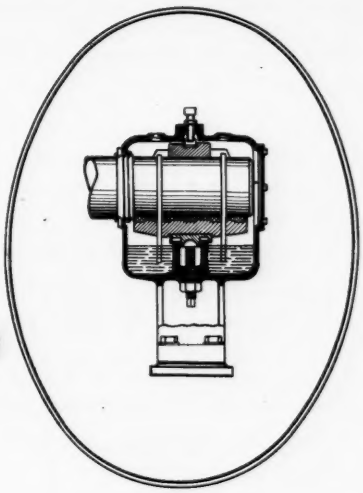
TO DETERMINE whether the high tides of the Bay of Fundy can be harnessed without harm to fishing along the coasts of New Brunswick and Maine, an international commission has been formed, according to a recent announcement.

Canada will be represented on this commission by W. A. Found, deputy minister of fisheries, and Dr. A. G. Huntsman, senior director of the Dominion biological board. United States representatives are Henry O'Malley, commissioner of fisheries at Washington, and O. E. Sette, officer of the United States bureau of fisheries. The commission will begin its work next month with Mr. Found as chairman.

The commissioners are associating with them in an honorary capacity an advisory committee of scientific men, made up of Dr. A. W. H. Needler, of the staff of the biological board of Canada, Prof. F. Ronald Hayes of the department of zoology at Dalhousie University, Halifax, Dr. H. B. Bigelow of the Wood's Hole, Mass., Oceanographic Institution, and Prof. A. E. Parr, of the Bingham Oceanographic Foundation at Yale University. Dr. Charles J. Fish, director of the Buffalo Museum of Science, has been appointed executive secretary of the commission.

PUMP SLIP varies from 2 to 40 per cent depending upon the condition of the valves and piston. Eight per cent is perhaps an average figure for piston pumps in good condition.

DIESEL ENGINE UPKEEP



PART XV. LUBRICATION OF POWER CYLINDERS, AIR COMPREESSOR CYLINDERS AND BEARINGS. CAUSES OF CONTAMINATION OF LUBRICATING OIL AND METHODS OF TESTING AND PREVENTION. DETAILS OF LUBRICATING EQUIPMENT. BY EDWARD J. KUNZE

LUBRICATING SYSTEMS for Diesel engines may be classified into three groups: power cylinder; air compressor cylinder, where air injection of fuel is employed and bearing lubrication. Cylinder lubrication in an internal combustion engine involves a burning process in which lubricant exposed to the combustion heat of the cylinder must be burned up completely if the piston speed is slow enough to permit ignition of the lubricant. Under such conditions there is no spreading effect to the oil such as that produced by repeated reciprocating movement. Oil for this purpose, therefore, must have additional properties and lubrication must receive special consideration.

Since the lubricant for power cylinders must seal the piston against "blow-by" between it and the cylinder, as well as lubricate both cylinder and piston rings, further special functions are required of cylinder oil for Diesel engines. The best lubricating system, therefore, would appear to be one in which cylinder lubrication is separate from bearing lubrications using oils especially adapted for these purposes, carefully selected in each case.

Use of inferior lubricating oil may result in sudden breakdown of the oil and formation of gummy deposits which are not always easily detected because the oil may seem to be in fairly good physical condition. Gummy deposits must be kept from oil pipes and ducts leading to the various bearings. Accumulation of such deposits may not be observed until flow to some bearing has ceased entirely, resulting in a burned-out bearing and other serious consequence. Faulty lubrication has caused many breakdowns. The user should rely upon the experience of the manufacturer in most cases and choose from the oils recommended the one which in actual use seems to be superior for his engine.

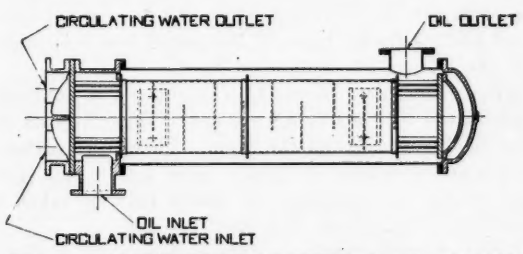


FIG. 1. CROSS-SECTION OF TYPICAL OIL COOLER

WATER CONTAMINATION

Contamination of oil by water is due principally to water condensation formed in intercoolers of air compressors, some of which, notwithstanding the intervention of the usual water separator, is carried over. Free water carried along with the air interferes with the formation of an efficient oil film on the cylinder wall, making the maintenance of a proper piston seal difficult. Presence of moisture also causes rusting of valves, piston rings and cylinder wall. Rust formation causes valves to pit and deposits a grinding medium between piston rings and cylinder wall, increasing the wear. Water may leak in, also, from the water cooling system. Water contamination should be prevented in order to avoid emulsification, hence clogging of pipes and ducts.

Viscosity influences the amount of oil required for adequate lubrication. If a bearing oil is too heavy in body, loss will occur due to high fluid friction and the separation of impurities, which unavoidably have entered the system, will be made more difficult. Use of too heavy oil has a detrimental effect on the life of the oil. Oil which is too light in body may not be able to maintain an effective film, resulting in metal to metal contact. Such an oil is atomized to a far greater extent, also, on leaving the bearings. This results in a more intimate contact with the air, consequently in more rapid oxidation. Use of too light an oil increases the oil consumption of a bearing.

OIL COOLERS DECREASE OIL CONSUMPTION

By increasing the working viscosity of an oil, oil coolers, such as shown in Fig. 1, have considerable effect, in some cases, on the oil consumption. Another simpler oil cooler for smaller units, which consists of a galvanized sheet iron jacket around a 2-in. pipe, is shown in Fig. 2.

Efficiency of lubrication is not impaired if crankcase oil gets no hotter than 135 deg. F. When a cooler is used, the oil should be cooled to about 100 deg. F. Lubrication will not be improved by lowering the temperature in this way, but oil consumption will be de-

creased because the oil will retain its body longer. Where the piston is oil cooled, the cooler performs the double service of reducing the oil temperature for piston cooling as well as for lubrication purposes. The temperature of the oil as it drains to the sump should be watched. A rising temperature indicates a hot bearing in which case the oil pressure should be raised temporarily, by setting a higher relief valve pressure, until the engine can be shut down and inspected.

Soft Water for Oil Coolers

As in cylinder jacket cooling*, the cooling water for oil coolers should be soft, preferably of zero hardness.

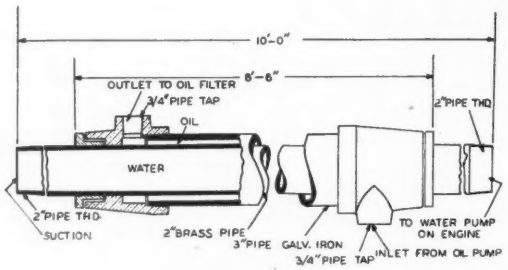


FIG. 2. OIL COOLER FOR SMALL UNITS CONSISTS OF JACKET AROUND PIPE

If hard water is used directly, deposits will form on the cooling surfaces, thus impairing the heat transfer rate and resulting in higher cylinder temperature and other undesirable consequences.

Advice of builders regarding viscosity of the oil to be used is valuable but it is difficult for them to specify correctly the proper viscosity for different operating conditions. This responsibility, after all, falls upon the

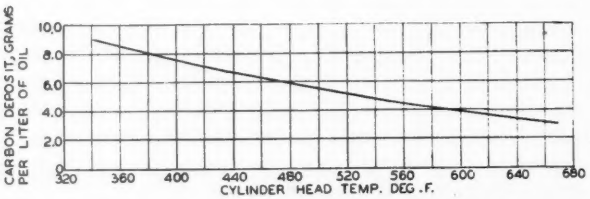


FIG. 3. EFFECT OF TEMPERATURE OF CYLINDER HEAD ON CARBON DEPOSITION

operating engineer; he should determine the best oil for his engines running under the conditions that confront him.

Determination of this is not difficult if test runs are made and proper records kept. The record sheet for this purpose should contain the following data: bearing clearances, diameters of the cylinders parallel to the crankshaft at the top and bottom, diameters at right angles to the crankshaft at top and bottom, condition of rings, number of rings stuck and partly stuck, amount of carbon in exhaust ports and manifolds and the amount of carbon on the exhaust valves, cylinder head and top of piston. Comparison of these data taken from test runs with different lubricating oils will indicate the best oil to use.

Carbon depositing tendencies of lubricating oils can be predicted approximately from the carbon residue of such oils. This carbon residue is a rough indication of the volatility, at flame temperature, of these oils. Determination of carbon residue is made quite accurately by the Conradson method but a hot-plate test, which can be made with a simple domestic-type of electrically heated hot plate, will determine the relative tendency to form carbon residue. The test is made by bringing the plate to the requisite temperature, then depositing on it a drop of the oil to be tested. Resulting smudge or carbon residue, which will remain after vaporization of the lighter, more volatile fractions, will indicate the relative degree to which the oil will probably develop carbon deposits in actual service. This test is purely relative; erroneous conclusions may be made if oils of different viscosities are compared.

Another simpler test for residues consists of placing a small quantity of the oil in a test tube along with about 20 times its volume of 85 deg. Baumé gasoline.

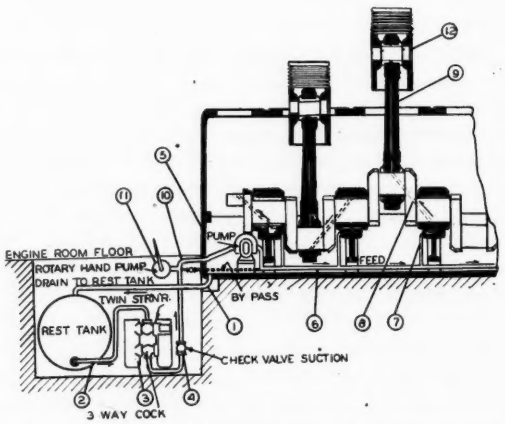


FIG. 4. PRESSURE LUBRICATION FOR BEARINGS

Allow the mixture to stand for an hour; any tar or other insoluble matter present will collect at the bottom of the test tube.

Detection of Gummy Matter and Sulphur

Gummy matter in an oil may be detected by placing a small amount of the oil on a piece of glass; the residue left after evaporation will reveal the amount of gummy matter carried.

If an oil contains any sulphur, a piece of highly polished copper will become tarnished after being suspended in the oil for 24 hr. The simplest test for sulphuric acid is to wash a sample of the oil thoroughly with warm water and test the water with neutral litmus paper. If even a faint reddish tint appears on the paper, the oil should be rejected. To determine the base of the lubricant, drop a little of the oil on a piece of paper. If, upon evaporation, the paper returns to its original color, the oil has a paraffin base; if the paper has been darkened, the oil has an asphaltum base.

When incomplete combustion is allowed to continue, carbonization will nearly always occur, especially on the piston head and around the rings. Therefore, carbonization may be caused by faulty valve action and stuck piston rings. Development of sludge may be taken as a qualitative indication of carbon residue.

Effect of temperature on carbon deposition is shown

*See Part V, Aug. 15, 1930, Power Plant Engineering.

graphically in Fig. 3, which is plotted from experiments by Marley, Livingstone and Gruse.

Accumulation of carbon deposits will be indicated, primarily, by loss of power not only because of loss of compression but of overheating due to loss of heat transference. Carbon deposits, on the inside of oil-cooled pistons, retard the transmission of heat from the piston to the cooling oil.

Oxidation Caused by Splashing in Air

In crankcase lubrication where the oil is splashed around by the crankshaft, the finely divided oil comes into intimate contact with the hot air in the crankcase, producing an oxidizing effect on the oil. This is especially true of crankcase compression engines and special care must be exercised in such cases. Use of inferior oil for this purpose results in a breakdown of the oil and a separation of its constituents.

Products of oil oxidation which are soluble at the temperature of operation and insoluble at normal room temperature, will be precipitated in a settling tank, the perfection of the process depending upon the length of time allowed for settling. Many of the minute particles of carbon will not settle out of the oil, however, and a first class filter, filter press or preferably a centrifuge, is necessary. Methods of reclaiming lubricating oil will be discussed in the next article of this series.

Many other causes of deposits, other than that of carbon in the lubricating oil, combine with carbon deposits in reducing the efficiency of the engine, if they are permitted to exist. Such causes are: faulty timing of the engine valves, too high or too low injection air pressure, leaky fuel injection valve and too low compression pressure.

Over-Lubrication

Bearing lubrication in Diesel engines differs widely from cylinder lubrication in that there is no limit, so far as it affects operation, to the amount of oil that should be used in the former case. In the latter case, however, whether it be for power or compressor cylinders, over-lubrication is a serious fault since it leads to abnormal carbon deposit in such cylinders. This effect is more pronounced in four-cycle engines than in the two-cycle type because in the latter the excessive oil is blown out through the exhaust ports. Over-lubrication may result, however, in such a deposition of carbon near the ports as to restrict the exhaust area and prevent proper scavenging.

Unfortunately there is no oil which will not deposit some carbon; on the other hand, there is a vast difference in the nature and quantity of this carbon which will be developed by different oils. Consequently, not only must cylinder oil be selected carefully but, whatever its characteristics, utmost care should be exercised to prevent use of more cylinder oil than is necessary.

If the cylinder oil used is too heavy in body it will not distribute rapidly enough, hence it will be necessary to feed larger amounts to prevent formation of dry spots. This over-feeding results in excessive carbon deposits. It is essential, therefore, that cylinder oil having proper body be selected.

Discharge of white or bluish smoke at the exhaust is an indication that too much lubricating oil is being supplied to the cylinder but this may come from other causes. Broken wiper rings at the bottom of the piston will allow an excess of oil, thrown up from the cranks, to work into the cylinder or the rings at the bottom of the pistons may be gummed up, allowing oil from the cranks to work up into the cylinder. This is not likely to happen on all cylinders at once, hence the cylinder affected may be determined by opening the cylinder pet cocks and noting the color of the exhaust. An excessive spray air pressure at light loads will cause a white exhaust similar to that caused by excessive lubrication.

Lubricant Consumption by Diesel Engines

No hard and fast rule can be laid down for the amount of lubricating oil that should be required by a Diesel engine because of wide variation in design and in operating conditions but if the engine is not developing

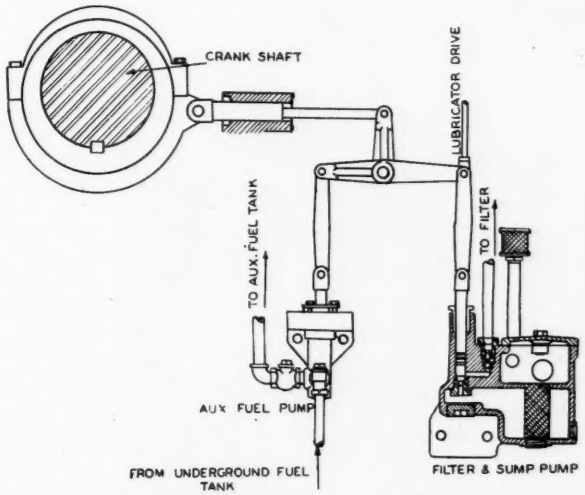


FIG. 5. ECCENTRIC DRIVE FOR FORCE-FEED LUBRICATOR

from 1500 to 2000 kw-hr. per gallon of oil, its lubrication system should be inspected.

While hand-supplied oil cups and even splash lubrication are giving place to force feed or pressure lubrication for cylinders as well as journal bearings, many are now in use hence regular attention to them on scheduled periods is essential procedure. Lubricators should be well supplied with oil. Linkages and sliding parts not automatically lubricated should receive regular and frequent attention.

In splash lubrication, the operator has no control over the rate of feed hence baffle plates or special scraper rings are used to reduce the quantity of oil which reaches the cylinder wall but this quantity is usually liberal. In ring oiling, splash lubrication or in any system in which the oil reservoir is in close connection with the lubricated part and in which the used oil flows back into the reservoir, care must be taken to prevent the oil from becoming too badly contaminated.

Devices to give warning when the oil film breaks are in the market. These serve to give warning when to change the lubricating oil and guard against overheating and scoring or burning out of bearings through failure of circulation, loss of viscosity or other similar cause.

In splash lubrication, oil may be prevented from leaking out through the bearing by attaching a throw-off disk to the crankshaft at the bearing inside the crank-

case. This is of especial use in crankcase compression engines. Any oil moving out along the shaft will be thrown off by centrifugal action.

Force Feed Lubrication

Forced feeding for bearings, when reclamation of lubricant is practiced, has advantages over drop feed lubrication in that sensible heat is carried away by the flowing liquid, deposits of foreign matter are not permitted to accumulate, the lubricant is kept purified by continuous or batch reclamation and the increased pressure under which it operates serves to maintain the oil film between the wearing surfaces.

Pressure lubrication for bearings is illustrated in Fig. 4. After flushing the bearings, the lubricant collects in the bedplate and flows through (1) into a large rest tank where it releases entrained air and moisture which has condensed on the inside of the crankcase. The pump draws the oil from the rest tank at (2) through either side of a twin strainer (3) discharging it into a main header (6) with a riser (7) at each bearing and passages in the crankshaft (8) and connecting rod (9) leading directly to the main bearings, crankpin and piston pin (12). Installation of a ball-check valve at the base of the connecting rod keeps the rod charged with lubricating oil when the engine is not running, thereby facilitating starting the engine.

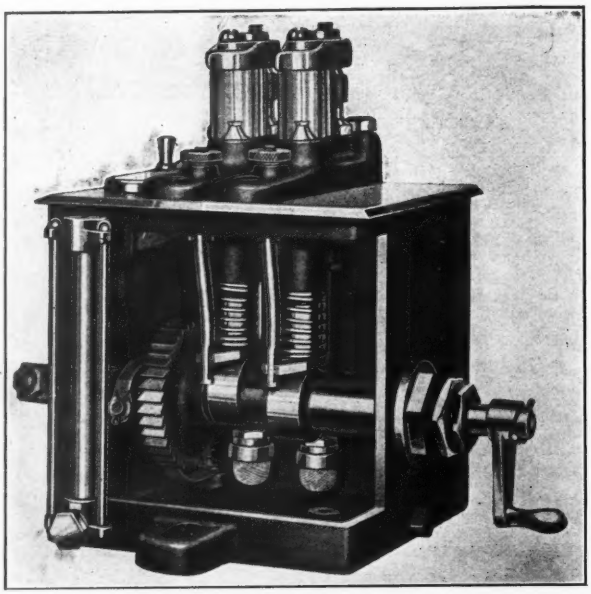


FIG. 6. TYPICAL FORCE-FEED LUBRICATOR USED FOR CYLINDER LUBRICATION

Application of an eccentric drive for a force-feed lubricator is illustrated diagrammatically in Fig. 5.

Rotary and gear-type pumps, as well as plunger pumps are used for forcing the oil and in some cases the oil is forced to an elevated tank in which case the lubricating pressure is furnished by gravity. In many cases the pump is enclosed in the crankcase and runs in oil. Lubrication for bearings should be positive and uniform, the pressure carried is usually about 15 lb. per sq. in.

Force-feed lubricators, such as that shown in Fig. 6, are used increasingly for cylinder lubrication, a separate pump and feed line being supplied for each cylinder. In the illustration, a lubricator with two feeds is shown. This lubricator is so constructed that any pump unit can be easily removed without disturbing the mechanism and permitting the remaining units to continue functioning as before. The oil line fed by the removed unit is not disturbed. The oil line remains full due to location of a check valve at the tank outlet and the oil will flow immediately when the pumping unit is replaced in the tank.

Lubricator Under Pressure Control

Gages that indicate the oil pressure are provided sometimes to control the pump. Some operators prefer to have two lubricating-oil gages connected to their lubricating system; one at each end of the header. Such arrangement provides a double check on the pressure. Cylinder lubricators of the type described may be timed with the stroke of the engine so as to admit the oil exactly at the best moment. Automatic engine stops are now being provided to give warning and stop the engine in case of failure of flow of lubricating oil.

Power cylinder lubrication should be checked every time the cylinder head or an engine valve is removed, by examining the cylinder at the top of the piston travel. A cigarette paper pressed against the cylinder wall should be dampened slightly but not soaked with oil, under proper working conditions.

At Chute-a-Caron on the Saguenay River, Quebec, Can., the great hydroelectro project of the Alcoa Power Co. is rapidly nearing completion, according to recent reports. The station is designed to contain four waterwheel generating units, each of which, it is stated, will be capable of producing 77,000 hp., or a total for the four units of 308,000 hp., although the units are normally rated at 65,000 hp. each. Two units have been installed and work is going forward on the two remaining units.

The Chute-a-Caron hydroelectric plant was built to provide electric power for a large metallurgical industry planned at Arvida by the Aluminum Co. of Canada. The industrial processes of this industry require large quantities of power for use in electric furnaces and for the production of aluminum by an electrolytic process. The present development is the first part of a two-stage development of the water power of the Saguenay River at this point. It is planned ultimately to produce about 1,000,000 hp. when another plant is erected in the future, to be known as the Shipshaw plant, two miles from the present plant.

Production of electricity by the electric light and power industry of the United States for the week ended Saturday, June 27, was 1,592,501,000 kw-hr., according to the Statistical Research Department of the National Electric Light Association. This is 3.9 per cent below the corresponding period in 1930.

The Atlantic seaboard shows a decline of 0.1 per cent in electrical output from last year. The great central industrial region, outlined by Buffalo, Pittsburgh, Cincinnati, St. Louis and Milwaukee, registers, as a whole, a decrease of 6.7 per cent, although the Chicago district shows a decrease of but 0.1 per cent. The Pacific Coast shows a drop of 3.8 per cent below last year.

Control of Electrical Equipment *in* Industrial Plants

Part IV

by E. H. Stivender

THERE ARE A NUMBER of different methods for the reliable and economical operation of indicating lamps for circuit breakers. Figure 1 illustrates one of the most suitable methods, it consists of energizing the red lamp through the trip coil when the circuit breaker is closed. This method allows a constant check, while the breaker is closed, as to the condition of the trip circuit; but should a protective relay close and the switch fail to trip, the red lamp will be dark. This is not necessarily an objection, however, since the green lamp, indicating open, will not light until the switch opens. The practice of operating the red lamp through the trip coil is a desirable one, and permits the use of a minimum number of control wires between the circuit breaker and control station, it is not always permissible, since some trip coils, especially those of some air-break circuit breakers, will operate on the small lamp current.

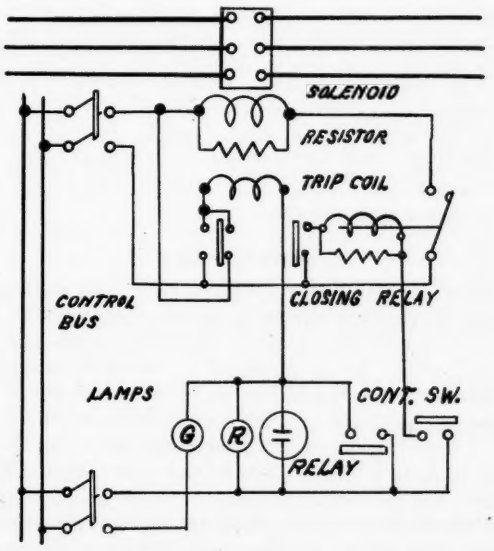


FIG. 2. A LAMP CIRCUIT WHICH ALTHOUGH POSSESSING UNDESIRABLE OPERATING CHARACTERISTICS REQUIRES A MINIMUM NUMBER OF CONTROL WIRES

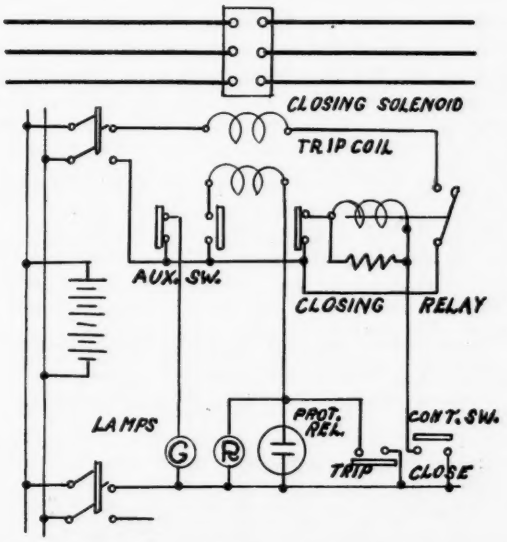


FIG. 1. ILLUSTRATING THE USE OF KNIFE SWITCHES AND A COMMONLY USED INDICATING LAMP CIRCUIT

Nearly always, the green lamp circuit in this system must be independent; it can seldom be safely operated through the closing relay coil since this coil is, as a rule, responsive to weak currents. Figure 1 shows a closing relay circuit using a hesitating relay; this type of relay stays closed for a short interval after its coil circuit is opened and hence can be operated in series with an auxiliary switch on the circuit breaker, which opens when the breaker closes. Even though the lamp current may not be of sufficient value to cause closing of the relay, it will be enough to hold the relay closed after it has been operated from the control switch. Should the closing mechanism collapse, due to action of the trip-free when the closing solenoid is energized, the auxiliary contacts which are operated by the main contact lever will not open the closing relay circuit; hence, even after the control switch is opened, the solenoid will be held energized, due to the action of current through the green lamp and closing relay coil. This will eventually result in a damaged solenoid.

Figure 2 shows a control circuit in which the closing, tripping, and indicating lamp operations are accomplished through two wires between the control station and the circuit breaker. This circuit has an objection which is also present in Fig. 1; however, it eliminates one wire. If the tripping contacts of the control switch are closed and immediately opened before the circuit breaker has time to open and thus open the trip circuit by operation of the auxiliary switches, the trip coil discharge current will flow through the red lamp. The voltage thus produced across the lamp may be of sufficient value to cause destruction of the filament. This is not so likely to take place where a transformer is used instead of a battery, since alternating current trip coils are of much lower inductance than direct current coils, hence a lower discharge voltage will be produced. On

direct current circuits of this type, it is sometimes advantageous to connect a resistor across the trip coil terminals, thus preventing the building up of excessive discharge voltages; however, most lamps will withstand this momentary voltage.

Another objection to the circuit of Fig. 2 is that should a relay close, due to abnormal load conditions and the trip mechanism fail to operate, the red lamp will become dark and the green lamp will light, giving a false indication of the position of the circuit breaker; hence an overload may remain on a motor while the indicating lamps will show it removed.

A circuit which has been used in the past to a great extent is a modification of Fig. 2. The lamp wire is independent of the trip wire, thus requiring three control wires to the circuit breaker. This circuit has little or no advantages over that of Fig. 1. Any circuit such

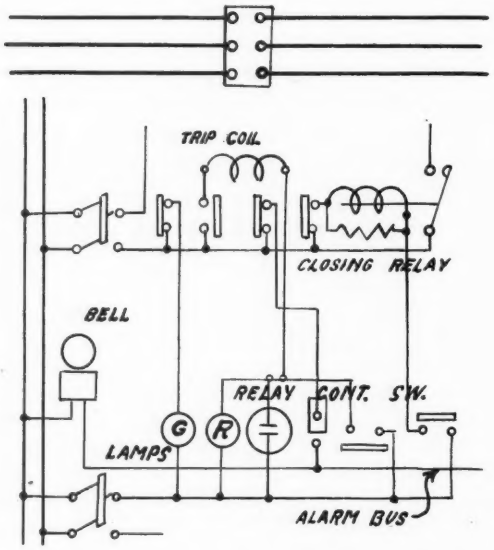


FIG. 3. THE USE OF AN AUXILIARY CONTACT ON THE CONTROL SWITCH FOR OBTAINING AN AUDIBLE ALARM WHEN A CIRCUIT BREAKER OPENS FOR ANY REASON OTHER THAN HAND TRIPPING

as Fig. 2, which uses one wire to operate two lamps has the disadvantage of burning the lamps in series when the control source is opened at the circuit breaker, by opening of the knife switch.

In cases where a number of switches are operated from one control panel, it has been found advantageous to open the green lamp circuit when a circuit breaker is to be left out of service for some time. This reduces the energy consumed by a number of lamps in operation which are of no particular service. It also tends to improve operating conditions by permitting the operator immediately to locate a switch which has tripped out automatically, since no other green lamps are burning.

Another scheme which facilitates location of a circuit breaker which has tripped out is that of using a lamp resistor with a tap to obtain two values of resistance inserted in the green lamp circuit. When the control switch is turned to "close" position, a contact is closed which places a short circuit on a section of the series resistor in the lamp circuit, this short circuit remains on after the control switch handle is released, when the control switch is turned to "trip" position the short-circuiting contact is opened. Should the circuit breaker be opened, due to relay operation or any other reason the green lamp will burn bright due to a portion of resistance being short-circuited. Since operation of the control switch removes the short circuit, the lamp will not burn at full brilliancy when the circuit breaker is tripped manually, hence those breakers which have been tripped manually will be indicated by dim lamps, while one which trips automatically will be conspicuous by a bright lamp.

As an assistance in finding which self-resetting relay has operated, target coils on each relay which are energized when the relay contacts close are provided. Different types of relays use different methods of operating indicators by target coils.

Alarm Circuits

It is usually desirable to have some audible alarm which sounds when a circuit breaker opens automatically. In exceptionally noisy places, klaxons are sometimes preferred, while bells cover a wide field of use in all locations.

Modern protective relays are generally provided with additional contacts which close the circuit to a hand-reset auxiliary relay upon operation of the trip contacts. The auxiliary relay energizes the bell circuit until its contacts are opened by hand. Another scheme, which may be used where extra contacts in the protective relays are not available, is to provide a bus at the switchboard from which control power for the relay contacts is furnished. A low resistance hand-reset relay, or a low resistance self-reset relay operating a hand-reset relay, is connected between this relay bus and the main switchboard control bus; thus, when any relay operates, the current through the contacts and the circuit breaker trip coil must pass through the auxiliary relay between the relay bus and control bus.

The two foregoing systems will cause operation of the alarm only in case of relay operation. It is sometimes desirable that the alarm be sounded when any circuit breaker opens due to any other cause. Figure 3 is a diagram of such a scheme. A contact is provided on the control switch which is closed when the control switch is turned to "close" position and remains closed after the handle is released. Should the circuit breaker open, due to any cause other than energizing the trip coil by operation of the control switch, the bell circuit will be closed. The bell will also be sounded during the interval between closing of the control switch and closing of the circuit breaker.

Closing Circuits

When closing circuit breakers by remote control, it is desirable that the circuit breaker be free to trip, even though the closing relay circuit is energized. Such trip-free action may be accomplished by use of several types of trip-free relays manufactured for such service, but the present preference is for a mechanical trip-free circuit breaker mechanism. Mechanical trip free mechanism consists of links between the operating motor or solenoid and the circuit breaker contacts which collapse upon operation of the trip mechanism; thus the solenoid plunger may be in the closed position while the circuit breaker contacts are free to open. The trip-free feature in any control circuit is a valuable protection against

severe damage caused by closing in on short circuit. Protective relays are free to trip the breaker at all times.

Hesitating control relays are of advantage in cases where the control switch may not be held in the "close" position until the breaker latches. These relays may have a heavy copper sleeve placed on the outside of the core, thus delaying the time in which contacts will open on interruption of the coil circuit; this action is by current induced in the copper sleeve which retains the flux for a short interval. A resistor across the closing relay coil terminals, or across the solenoid terminals, or both, tends to accomplish a hesitating action.

Most motor operated circuit breakers are provided with a means of "sealing" the closing relay closed until the mechanism has latched in closed position.

A resistor across the closing solenoid also reduces the discharge voltage, which may be destructive to other apparatus in the control circuit, especially ground detector lamps. Where single-pole contactors are used for closing relays, it is possible for the solenoid discharge voltage to build up excessively between ground and the solenoid terminal which is connected to the contactor, due to the other terminal being grounded through ground detector lamps. This may result in burned out lamps or lamp sockets and possibly to injury to the solenoid insulation to ground.

In 125-v. d.c. control circuits, it is permissible to use single-pole contactors for closing relays. In most cases, it is necessary to use double-pole contactors in 250-v. circuits. It is also preferable to connect two control switch contacts or two auxiliary relay contacts in series for each circuit when 250-v. control is used, this practice will decrease contact deterioration and more serious damages due to excessive arcing.

The use of closing contactors with too light a movable element will often result in burned out solenoids. Residual magnetism or burning of the contacts is sufficient to hold such relays closed after the control switch is opened.

Automatic Control

Auxiliary switches used on circuit breakers are mostly of either the knife or the drum types. Drum types are usually more compact and offer provision for the addition of extra contacts where desired, they also provide a double break on opening which is advantageous on 250-v. d.c. control circuits. Knife switches have the feature of being somewhat more accessible, but requiring more space.

Accessibility to control apparatus is an important item in any installation. Terminal blocks behind switchboards should not be mounted so close to the panel as to interfere with inspection and maintenance of other apparatus. All terminal boxes, circuit breaker auxiliary switches, relays and fuses should be readily accessible; work on any apparatus should not require much dismantling of other equipment.

In automatic control circuits, electrical or mechanical interlocking of different circuit breakers should be provided so that it will be impossible for any incorrect sequence of operation which might result in damage to equipment to take place. Extra contacts in auxiliary switches and auxiliary relays and extra wires in conduits are very desirable, since occasion often arises where it is necessary to make use of such material without disturbing existing equipment.

Ground detector lamps are frequently desirable. A ground remaining in a control circuit may sometimes lead to unfavorable results, such as short circuits or accidental operation of circuit breakers. For locating grounds in control circuits the use of sufficient knife switches to isolate sections of the control system are an asset. Their installation is inexpensive, since owing to only occasional operation being required, they need not be mounted on the fronts of control panels but may be placed at favorable positions on backs. When a common control bus is provided for the operation of a number of circuit breakers a knife switch should be provided at each breaker. They should be so installed that the control circuit of each individual motor may be deënergized.

Since it is often desirable to locate the vicinity of a grounded control circuit while a machine is in operation, it is important in automatic control installations that the master relay and other normally energized devices do not become deënergized. Circuits to these devices may be run independently of other control knife switches or through individual knife switches. Of course it is not always considered necessary to complicate control circuits further by the use of a great number of knife switches. In any case, it should be possible to deënergize completely the control system of each motor in order to provide for maintenance work.

As a protective measure against damage to closing solenoids, due to accidental prolonged operating current, correct size fuses may be installed between each solenoid and the control bus. The inherent time element of the fuse will allow sufficient energy for closing to pass, but if the time limit is exceeded the fuses will blow. Care must be taken that the trip circuit does not go through these fuses.

Where it is desirable to insert fuses in the control circuit at the switchboard, the trip circuit should be independent of the fuses.

It is generally recommended by manufacturers to ground all instrument cases. A.c. instruments such as ammeters and relays should have the cases grounded, owing to the possibility of an open ground circuit of the current transformers secondaries. Should a person touch an instrument case while such a condition exists, the voltage to ground, due to possible internal arcing to the case, might be excessive.

Direct current ammeters in the field circuits of synchronous motors should be grounded, owing to the high potentials present in field circuits during starting periods.

Atlantic City has been chosen as the convention city for the exhibit and 55th Convention of the National Electric Light Association, June 6 to 10, 1932, in the Atlantic City Auditorium and Convention Hall. This announcement was made by Paul S. Clapp, managing director of the Association, following a decision of the officers of the Association who were elected at the 54th Convention in Atlantic City in June.

Transmission problems play a large part in hydroelectric developments because they are usually a considerable distance from the load center.

Practical Electrical Apparatus Lubrication

HARMFUL EFFECT OF OIL ON INSULATING MATERIALS MAKE LUBRICATION OF ELECTRICAL MACHINERY MORE DIFFICULT THAN THAT OF NON-ELECTRICAL MACHINERY

ALTHOUGH THE LUBRICATION of machinery is of necessity an age old practice, evidence is not lacking that much remains to be learned about getting the right kind of lubricant in the best way to do the most good.

In a paper presented recently before the convention of Iron and Steel Electrical Engineers, J. L. Brown of the Industrial Motor Engineering Department of the Westinghouse Electric and Mfg. Co. discusses the lubri-

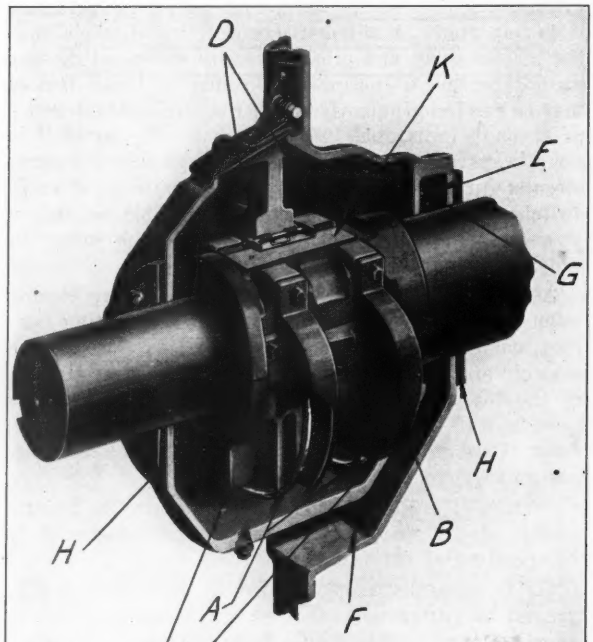


FIG. 1. TYPE OF OIL RING BEARING WHICH ABSOLUTELY PREVENTS ESCAPE OF OIL.

cation of machinery used in steel mills. While there are special problems in connection with steel mill lubrication, on the whole the principles which underly the proper lubrication of steel mill equipment are also applicable to electrical machinery used in other places, and for this reason certain portions of Mr. Brown's paper will be of interest to other engineers not necessarily concerned with steel mills.

Lubrication of an electrical machine is more complicated than that of non-electrical machinery, due to the presence and nature of insulating materials and the practice of passing ventilating air over the insulation surfaces.

Nearly all motor bearings now in service are of the plain or sleeve type, the larger types usually being "split."

For continuous operation, these bearings when properly designed, are ideal. Enormous weights are sustained with a minimum of friction by the simple expedient of introducing oil between the bearing and the shaft at the side opposite that carrying the load.

These bearings are simple, simply repaired or renewed, and nature's own anti-friction medium is pressed into service with a minimum of "harness" and with maximum effect. The marvels of the mechanism of lubrication is a story of compelling interest. Within a few inches of the circumference of this simplest of constructions, the oil pressure is built up from zero to as much as 500 lb. per sq. in. without pump pistons, centrifugal runners, valves or gaskets and at even low rotational speeds, so that even the most massive rotors of main roll driving motors actually as well as theoretically float on oil.

Failure of the fluid film which occurs in the plain bearings of some apparatus (roll neck bearings, for example) due to the building up of excessive unit pressures, is not normally encountered in electrical machinery, as it is usually feasible to provide adequate bearing area. The chief difficulty arising in electric motor lubrication is in preventing oil from escaping from the bearing housing and spreading over the insulation with destructive effect.

The persistence of oil in filling and escaping through minute crevices, and in spreading over surfaces—especially rough or dirty surfaces—is a great asset from the standpoint of effective lubrication but it has been responsible also for large monetary losses due to direct maintenance expense in rewinding apparatus and to expensive shut-downs and delays in production. The suction produced adjacent to the bearing housings by the use of artificial ventilation has greatly accentuated the tendency of the oil to escape and it is only within the last few years that we have learned how to combat these tendencies effectively without in any way impairing the lubricating efficiency of the oil. Even in cases of serious leakage, the amount escaping in an hour or even a day may be very small but the aggregate in a year's time may be sufficient to be very destructive. It is essential, therefore, to permanency of the machine and its parts that oil leakage be eliminated entirely.

Oil leakage from split bearings, which, of course, entail split housings, has been particularly bad and particularly difficult to eliminate. Oil particles lodging on the upper interior walls of the housing collect into a film which runs down and finds ready egress through the capillary space between the upper and lower halves of the housing. Not only so, but this space acts as an axial duct to convey the escaping oil to any point where leakage occurs most readily, as where the proximity of a ventilating fan attached to the rotor results in appreciable suction, inducing the oil to escape into the air stream.

It has been recognized for a long time that the oil rings have been responsible for a great deal of oil

splashing in the bearing housings and the bearings have been fitted with guards shrouding the rings so that the oil splash would not be directed at the split or parting. Resort has been had to closing the parting with a sealer such as shellac or plumber's cement and many other schemes have been tried with only limited success.

Analysis of the situation disclosed the fact that if the interior walls of the housing could be kept as dry during operation as they are when the apparatus is not in use there would be no leakage during operation even as there is no leakage at standstill. Further investigation led to the discovery that even carefully guarded oil rings create a minute spray, too finely divided to be seen or to be appreciably affected by gravity. These minute particles float out from the rings and through the air space within the housing, finally lodging on the housing walls or are borne by air currents out along the shaft into the motor.

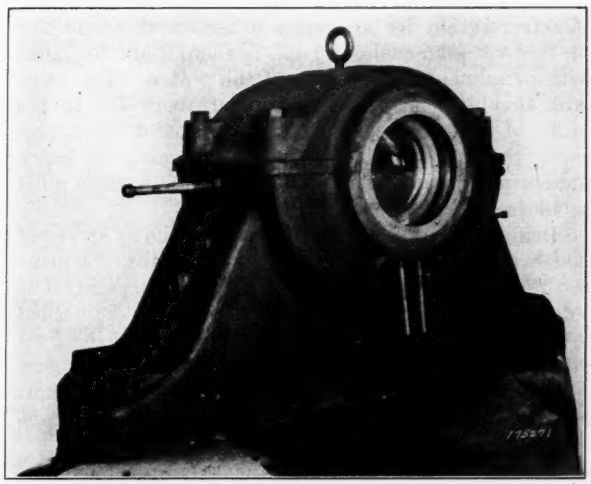


FIG. 2. PEDESTAL TYPE BEARING EQUIPPED FOR FLOOD OIL LUBRICATION.

In Fig. 1 is shown a design which absolutely prevents the escape of any oil particles from the oil rings A into the housing chamber, D. Not only are the oil rings guarded but they are completely enclosed within chambers, B, (shown partially cut away) which are open at no point above the level of the oil in the reservoir. The lower edges, C, of these chambers are about ¾ in. below the oil level. The sight holes at the top of the bearing for inspection of the oil rings are closed by a spring hinged and gasketed cover located in a recess draining back into the interior of the bearing. Dust-proofing washers, H, perform no part in preventing oil leakage as air currents may pass freely through the housing without danger of carrying with them any oil vapors. The inner walls of chambers, D, are at all times quite dry. The parting between upper and lower halves requires no sealer and may be open any amount without danger of oil leakage. The principle throughout is complete isolation of the oil rings or other spray forming parts of the bearing from the main housing chamber, thus simulating in this chamber, even during operation, the conditions obtaining at standstill.

Attention is directed to the chamber, E, which separates the inner end of the bearing housing from the interior of the motor and communicates with the atmosphere through a duct, F, below the oil reservoir. By this means, the air pressure established at the inner end of the housing is very slightly less than atmospheric, thus reducing the suction tendency to oil leakage to a very low figure regardless of the windage conditions inside the motor. Escape of air into the motor through the annular clearance space, G, is supplied at low velocity through the duct F instead of through the bearing housing.

Figure 1 is a perspective drawing of the Sealed Sleeve Split bearing. It has been giving perfect performance over a period of several years, so that it may be confidently stated that if this combination of features be applied there is no case of stationary motor bearing oil leakage that cannot be completely corrected.

Having achieved success with this design of leak-proof split bearing, a line of pedestal bearings has been developed for larger machinery incorporating these features.

High Speed Journals

As journal speeds increase beyond 1800 ft. per min., the normal flow of oil through a ring-oiled bearing is often insufficient for conducting away the heat, so that for the higher journal speeds, flood oil lubrication is used. The pedestal bearing illustrated in Fig. 2 is adapted to this type of lubrication, which can be used with or without oil rings. This type of lubrication involves the use of a direct driven or motor driven gear pump and oil cooling tank or radiator.

A number of applications of auxiliary motors in steel mills involve the movement of the motor bodily as in crane service. The rapid acceleration and deceleration of the crane or other apparatus often results in escape of oil from the motor bearings, some of which finds its way on to the commutator and windings of the motor. In some cases, heavy grease from the gear cases has flowed into the bearing housing settling into the bottom of the oil reservoir and preventing operation of the oil rings, resulting in failure of the bearings and subsequent damage to armature and pole pieces. As a result of such difficulties, considerable interest has developed in the application of ball and roller bearings to auxiliary motors. This new development has brought its own problems, and among them the lubrication problem has been one of the most outstanding.

James A. Powell, vice-president and assistant chief engineer of W. S. Barstow & Co., Inc., Reading, Pa., has recently been awarded the degree of doctor of science by North Carolina State College, Raleigh, N. C., in recognition of his outstanding work in the field of mechanical engineering. Dr. Powell has been associated with W. S. Barstow & Co. since June, 1919, successively as mechanical engineer, assistant chief engineer and vice-president and assistant chief engineer. At present he is stationed in the Philippine Islands to supervise the operation of the Botocan Falls hydroelectric development. Dr. Powell received his engineering education at North Carolina State College, graduating in the class of 1908. He has been associated with H. P. S. Keller, Raleigh, N. C., Westinghouse Machine Co. and Newport News Shipbuilding & Dry Dock Co. He has supervised the engineering designs of ten Associated power plant installations.

Building Ice Skating Rinks

MAINTENANCE AND CONSTRUCTION OF OPEN AND CLOSED RINKS DESCRIBED IN REFRIGERATING ENGINEERING BY MARTIN R. CARPENTER, CONSULTING ENGINEER FOR MANY FAMOUS RINKS

IDEAL ICE for skating is hard underneath, with a sweaty or damp, but not necessarily wet surface. Such a surface does not cut or snow and offers the least resistance to skates. The temperature of the body of the floor should be varied to meet different conditions but must be maintained at a suitable temperature to enable the air to control the surface. If there are a large number of skaters on the ice, with the floor temperature about 22 or 23 deg. F., the air temperature will have to be maintained around 40 deg. F.; whereas, if there are only a few skaters, it may be kept around 50 to 55 deg. F.

Should it appear desirable to maintain a higher air temperature, of, say, 55 to 60 deg. F. with a large number of skaters on the ice, the ice temperature will have to be lowered to around 20 deg. F. With a 20-deg. F. floor and only a few skaters, the air temperature may be raised to 55 or 60 deg. F. Each rink has its individual characteristics and these combinations must be worked out to some extent by experiment. Ice surfaces on semi-enclosed rinks cannot be controlled, as the temperatures depend solely on the outside air conditions and as a rule the ice is hard and apt to cut up and snow. Under some conditions in enclosed rinks, it may be necessary to circulate cold air, usually secured from the outside, although several rinks have been equipped with cold air bunkers or rooms containing coils on which a large quantity of ice is frozen and held in readiness for use when needed. These bunkers are, however, expensive to construct and maintain and are not required when the outdoor air temperature is 40 deg. or lower.

FLOOR SIZES AND REFRIGERATION REQUIRED

Areas for skating for rinks can be any size desired, but hockey rinks should not be less than 80 by 185 ft. in size and curling rinks must be at least 128 ft. long and about 12 ft. wide. On the basis of square feet of floor space per ton of refrigeration for rinks where the floor is maintained constantly, capacities vary from 120 to as high as 275 ft. Where the ice is removed periodically, it is necessary to increase the refrigerating capacity from 75 to 100 per cent.

Owing to great fluctuation in refrigerating demand, it is advisable to install equipment in multiple units. The Playland Casino, with a floor area of 16,640 sq. ft., has one 10 by 10-in. and one 9 by 9-in. vertical compressors operating at 300 r.p.m. This rink is fully enclosed and the temperature is maintained at 50 to 60 deg. The smaller machine carries the load for days at a time, but occasionally both machines are required for periods from one to three hours.

At West Point the U. S. Military Academy rink has a floor area of 20,700 sq. ft. and has two 9 by 9-in. vertical, single-acting compressors operating at 300 r.p.m. This is a semi-enclosed rink and since the first month of operation one machine has carried the load constantly with intermittent operation.

A 9 by 9-in. compressor, under the condition of operation at the West Point rink will produce about 42 t. of refrigeration effort so that one ton of refrigeration is carrying about 490 sq. ft. of floor area. The air temperature in this case runs from 26 to 36 deg. F. during the day.

BRINE TANKS

On an average, an allowance of 200 sq. ft. per ton of refrigeration for an enclosed heated rink and 250 sq. ft. for a semi-enclosed rink, is about right for rinks with permanent ice throughout the season. The brine tank should be based on a ratio of about 150 to 175 sq. ft. of floor surface to each cubic foot of brine, provided the refrigerating capacity is ample to carry sudden peak loads; if it is not, the brine storage must be increased.

Brine connections to the tank should be so arranged that brine may be bypassed. By this means, the brine in the tank may be cooled down to a low point, 0 to 5 deg. above and held in reserve until it may be needed to meet a sudden demand for colder brine in the floor piping. By this means, the circulated brine temperature is quickly reduced by 5 or 10 deg. F. for short periods, without changing the operation of the compressors.

During normal operation, the average brine temperature going into the floor should be from 14 to 16 deg. F. and the return from 15½ to 18 deg., although at times this difference may be considerably more. Some of the records of brine temperatures in Playland Casino and West Point rinks show an average difference between the incoming and outgoing brine of 1.5 to 2 deg. under normal operation. The Playland rink circulates about 800 g.p.m., which is a ratio of about 21 sq. ft. of floor surface to each gal. per min. There are 624 pipes (1-in. or 4-in. centers) in the floors and each pipe carries about 1.28 gal. per min.

West Point circulates 720 g.p.m. with one pump, or 1280 g.p.m. with two pumps. One pump is sufficient except at times when it is desired to freeze down a new coat of water quickly. This is a ratio of about 28.7 sq. ft. of floor surface to each g.p.m. There are 552 pipes (1-in. or 5-in. centers) in the floor and each pipe carries 1.34 g.p.m with one pump and 2.13 g.p.m. with two pumps.

SPRAYING

Ice on permanent floors is best made by repeated sprayings of water, each frozen before the next spraying. Usually about 1/32 in. of ice is formed at a time, except when first making the floor, when, if the floor temperature is down to 12 to 15 deg. F., the spray may be put on up to ¼ in. at a time.

A permanent floor for public skating should be

maintained from ¾ to 1 in. thickness and not more than 1¼ in., as beyond this thickness the floor is expensive to maintain during warm weather or with a large attendance. If the floor is to be used for one day only, it may be from ⅜ to ½ in. thick and, as this type of floor is usually prepared for hockey, it should be rather hard.

As an indication of the amount of refrigeration required to freeze the ice, considering the latent heat only, the accompanying table, giving the weight per square foot for various thicknesses and the total weights of ice and refrigeration required for an average rink of 80 by 200 ft. will be found useful.

Temperature of water used for spraying is a subject for argument, some contending that hot water is absolutely necessary in order to secure a smooth surface, while others contend that it is necessary to prevent shell ice; still others find no advantage whatever from its use. The author always used cold water

DATA FOR ICE ON A RINK 80 BY 200 FT.

Thickness in.	Weight total ice	Total heat B.t.u.	Refrigeration ton hrs.
1/32	2,395	344,880	28.74
1/16	4,790	689,760	57.48
⅛	9,580	1,379,520	114.96
¼	19,160	2,759,040	229.92
½	38,320	5,518,080	459.84
1	76,640	11,036,160	919.68

with the best results and is of the opinion that hot water is unnecessary, with the possible exception of outside outdoor or semi-enclosed rinks and then only when the temperatures are below 28 to 30 deg. F. Even under such conditions, water of 70 or 80 deg. F. is sufficiently warm to prevent shell ice, provided the ice is not completely flooded.

As the finer the spray the better, the type of spray nozzle is important. The nozzle should deliver a sufficient quantity of water for spraying the floor quickly. For a floor 80 by 200 ft., the spraying of one average coat of water should not require more than 15 min. at the longest.

Tools required consist of sufficient hose, preferably a 1-in. spray nozzle, an ice planer, a tractor to pull the planer, a snow catcher to collect the shavings from the planer, a set of three or four squeegees, 5 or 6 ft. long, a set of snow pushers with steel edges and possibly a steel snow pusher to work around the edges of the rink.

Washing is accomplished by pouring water along one side of the entire rink, then by means of two or three squeegees held at an angle the water is washed sideways across the rink, removing all the loose snow and slush which is pushed into the snow pit. This will require the work of three or four men about 10 or 15 min. After planing and washing the next operation is to spray the ice, and if the ice control system is properly operated the spray coat need not be more than 1/32 in. thick. An experienced ice crew will resurface and have the floor ready for use in approximately an hour.

GREENHOUSES raising violets and azaleas are kept at a temperature from 40 to 45 deg. F.; carnations, 50 to 55 deg.; roses and mushrooms, 55 to 60 deg.; orchids, 60 to 65 deg., according to scientists of the research department of The Petroleum Heat and Power Co. For general purposes a temperature of 55 to 60 deg. is maintained, and for forcing, about 5 deg. higher.

Mobile Plant Operation

DATA ON THE OPERATION of the steam plant built by the Southeastern Production Co. to serve the paper mill of the International Paper Co. near Mobile, Ala., were given recently in a paper presented before the T.A. P.P.I. This plant, which was fully described on page 884 of the May 1, 1930, issue, was built by the utility company for the double purpose of answering as a standby steam station for its system in southwest Alabama and to supply both steam and electric power to the paper mill.

Estimated power consumption of the paper mill was 8000 kw. with an annual steam consumption of one billion pounds of steam about equally divided between 35 and 150 lb. gage pressure. The power house consists

	British Thermal Units Annually
HEAT SUPPLIED TO PAPER MILL BY POWER PLANT:	
554,305,200 lb. steam for process—150 lb. ga. 120 deg. F.S.H.—1264 B.t.u.	700,641,772,800
494,742,000 lb. steam for process—35 lb. ga.—20 deg. F.S.H.—1184 B.t.u.	585,774,528,000
	1,286,416,300,800
Electric energy—61,646,172 kw.-hr.—3412 B.t.u.	210,336,738,864
Total heat energy supplied to paper mill	1,496,753,039,664

	British Thermal Units Annually	
TOTAL HEAT ENERGY REQUIRED BY POWER PLANT:		
Coal equivalent of bark—14,500 t. @ 26,000,000 Bt.u.	377,000,000,000	
Coal burned—56,450 t. @ 26,000,000 B.t.u.	1,467,700,000,000	
Purchased electric energy — 45,210,000 kwh. @ 3412 B.t.u.	154,255,620,000	
Condensate returned—453,000,000 lb. @ 150 deg. F.	53,454,000,000	
Raw water—620,000,000 lb. @ 70 deg. F.	23,560,000,000	
Total heat required by power plant	2,062,969,620,000	
Station service and losses—4,707,840 kwh. @ 3412 B.t.u.	16,063,150,080	
	2,059,906,469,920	
Condensate lost—596,447,200 lb. @ 272 deg. F.	108,480,590,400	
	1,951,425,879,520	
*Blowdown—23,952,800 lb. @ 225 deg. F.	4,622,890,400	
	1,946,802,989,120	
†Combustion losses — 24.40 per cent	450,051,949,456	
	1,496,753,039,664	1,496,753,039,664

of three 1300-hp., 450-lb. boilers and a 7500-kw. double extraction turbine. A standby condensing turbine rated at 2500 kv-a. was installed to enable the power company to carry the full paper load when necessary. Transformer facilities were provided to tie the steam plant in with the system of the Alabama Power Co. Bark and wood waste refuse is burned in a separate boiler connected with the power plant.

Normal operation of the plant is with the 7500-kv.-a. double automatic extraction turbine operating in parallel with the Alabama Power Co.'s system, the load on the machine being proportional to the steam requirements to the paper mill. To take care of momentary interruptions on the transmission system and to prevent total power failure at the paper mill, a system of relays operated through a frequency relay serves to disconnect that part of the paper mill load which may be classed as non-essential during a short interval and place the turbine on its speed governor.

*Continuous blowdown.
†Includes both bark burning boiler and main boiler plant.

Individual Drive for Modernizing Plants

TO MOTORIZE belt-driven machines so as to use individual drive, a unit is supplied by the Production Equipment Co. in ratings from ½ to 20 hp. for single or multispeed and one way or reversing drive, as illustrated herewith. With box type base as in Fig. 1, cone-pulley shaft and idler for taking up belt slack, as well as belt shifter are built in, permitting pulley centers to be as low as 18 in. The U-shape supporting members give a rigid mounting and distribute strain well.

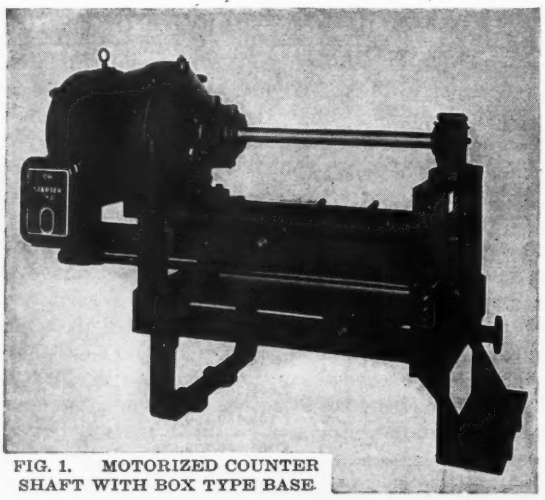


FIG. 1. MOTORIZED COUNTER SHAFT WITH BOX TYPE BASE

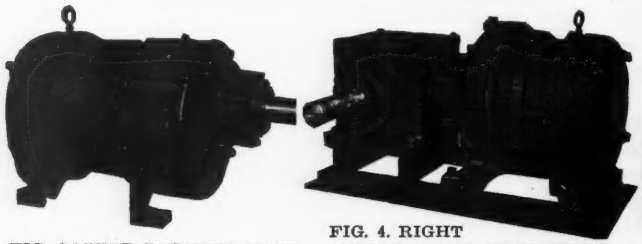


FIG. 3. SPEED REDUCER UNIT.

FIG. 4. RIGHT ANGLE SPEED REDUCTION

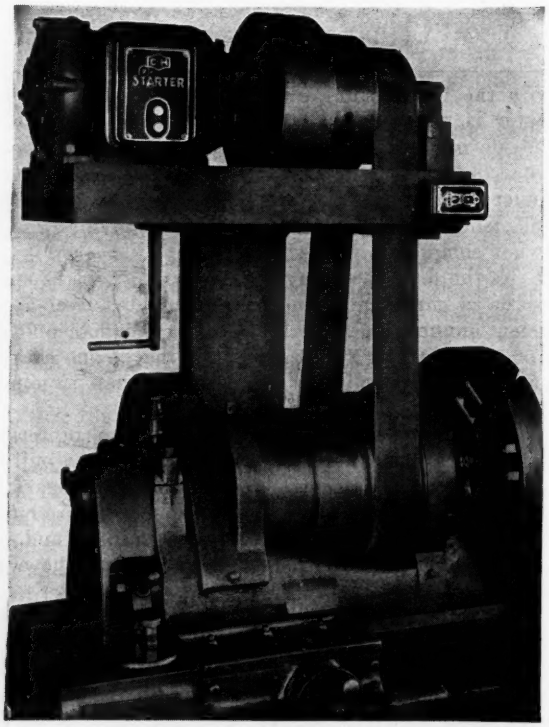


FIG. 2. OVERHUNG TYPE BASE FOR LATHE DRIVE.

For applications where support must be from one side, the overhung base is used, Fig. 2 and belt tension is adjusted by a hinge at the upper end of the column, the position of the base being regulated by a cam. While usually no idler or belt shifter is provided with this type, they can be supplied if desired.

Three types of speed reducer units are used; type A of Fig. 3 has a helical spur gear reduction in the front bearing bracket with the slow-speed shaft the same height as the motor shaft but offset to one side. Type B, Figs. 1 and 2 has a planetary spur gear reduction, permitting economical development of slower speeds and the drive shaft in the same center line as the motor shaft, so that a smaller base is possible, also better balance in mounting. Type C, Fig. 4 uses planetary reduction also bevel gears so that the drive shaft is at right angle to the motor shaft, a compact arrangement for some drives.

Units may be arranged for direct coupling as in Figs. 3 and 4, for belted power, single or coned as in Figs. 1 and 2 or type B may have the shaft extended at both ends of the unit for direct coupling or for belt pulleys.

This equipment gives the same advantages for direct drive to modernized tools and machines as does the built-in individual motor and avoids scrapping belt-driven machinery which still has useful life, or purchase of special motors to fit the speed of the driven machines.

Lighting Service for Factories

By O. H. Henschel

This may be provided by means of an independent system supplied by a centrally located transformer, or bank of transformers, or by the use of a transformer or bank of transformers located at points throughout the plant and fed directly from the power mains. Single-phase transformer units connected across any one of the phases are ordinarily employed but care must be exercised in connecting these to insure a maximum degree of balance.

Three-phase service can be and frequently is used. In that case, transformer units, of either the three-phase or single-phase, open or closed delta-connected types and with voltage ratios of from 440 to 220 and 110, or 220 to 220 and 110 are employed. The individual circuits can then be directly connected across the various secondary phases.

Where single-phase transformers with three-wire secondaries are to be utilized, potential or auto-transformers find a wide field of use, particularly with voltage ratios of 220 to 220 and 110.

All oil-cooled transformers should, of course, be housed in suitable vaults, provided for the purpose or included within the main sub-station.

Care must, however, be exercised in connection with the layout. These conductor sizes may be sufficiently large to avoid undue heating, yet not large enough to provide minimum permissible voltage drop of from 5 to 7 per cent. In general, the size of a long conductor will be determined by voltage drop and that of a short conductor by current carrying capacity.

Voltage drop in a two-wire, direct-current circuit may be determined by dividing the product of 21.6, the length of each conductor in feet and the current in amperes, by the cross-sectional area of the conductor expressed in circular mils.

This same rule is applicable to a three-wire feeder with balanced load and with consideration of the voltage existing between the two outside conductors. A neutral of a size the same as each of the two side conductors should then be employed.

Induction Motor Repair

For longitudinal rotor bars which persisted in breaking loose from the copper end rings, repairs had been made by piercing several light metal sheet rings for the bars to project through and soft soldering these to the bars. With heavy load the heat generated melted the solder.

As told in Oxy-Acetylene Tips, when the superintendent explained his difficulty to a welding engineer, it was suggested that the ends of the bars be welded to a heavy copper ring.

Next time there was trouble this was tried, the service engineer being called in to instruct the plant welder as to making the repair. High thermal conductivity of the copper ring made it necessary to use two blow-pipes, one with small welding head to keep the ring warm, the other with large head for the actual welding.

To insure penetration, welding was done in a vertical position, allowing the bronze to flow freely and 57 welds, each ½ in. long, were made in 25 min. Excess flux was cleaned off after the job was completed.

This bronze welding was approved by all concerned and will be used for all such repairs in future.

Metal Cleaning by Electricity

For cleaning metal articles prior to plating or when overhauling machinery, electric current may be used to advantage with an alkaline solution cleaning bath, similar to a plating bath as electrolyte. The method and details are given by D. E. Williard in Houghton's Black and White.

Current and Wiring

Wiring is the same as for a plating system, direct current of 20 to 35 amp. per sq. ft. of cleaned surface being used at 6 to 12 volts. The lower voltage and current are used for non-ferrous metals and for large work racked in tanks. Higher voltage and current are used for ferrous metals, for batches of small parts in tanks and for barrel cleaning. Unless current is available for 25 amp. per sq. ft., results obtained will hardly justify use of the process.

As operation is at low voltage, conductors must be of ample size to carry the current with little voltage drop. For a distance of 40 ft., a conductor of 1 sq. in. cross section will carry 1000 amp. satisfactorily. For a longer distance, the size of conductor should be increased in proportion, i. e., 2 sq. in. per 1000 amp. for 80 ft. Evidently it is desirable to have the low-voltage generator located as near the tank as possible.

Tanks and Electrodes

Unlined tanks of iron or steel are used, but a badly rusted tank is unsuitable, as the electrolyte is likely to loosen the scale and rust and cause leakage, especially if the tank is used as the anode of the electric circuit. In any case, it is better to use sheets of iron as anodes, since scale will eventually be formed and the sheets can be easily removed and cleaned. Use of small anode sheets makes for easier cleaning.

During the process, oxygen gas is liberated at the anode and hydrogen gas at the cathode. With the metal to be cleaned used as the cathode, called "cleaning by direct current," the hydrogen formed exerts a pressure at the metal surface to lift dirt from the surface. As hydrogen liberated is twice the volume of oxygen, it gives a greater cleaning effect, also avoids oxidizing of the surface. If a film of oxide remains on the surface, it interferes with plating hence, if work to be cleaned is made the anode, called "cleaning with reversed current," a final treatment of some 5 sec. should be given with "direct cleaning current" unless the work is to be pickled, in which case the pickling will remove the oxide film.

With current of 30 to 35 amp. per sq. ft., some 20 cu. in. of hydrogen per minute will be formed. Anode sheets may be 6 to 12 in. wide spaced 2 in. apart and extend from the supporting rod to within 6 in. of the bottom of the tank. They are placed 2 to 3 in. from the sides of the tank and at 6 to 9 in. from the work to be

cleaned. The ends of anode sheets bent 180 deg. around the rods will give ample support and contact.

Tanks should be insulated from the floor by glass or porcelain supports; also pipe connections for steam heating or for changing electrolyte should be insulated from the tank by rubber or other insulating material.

Steam coils for heating are located at the operator's side of the tank with provision for agitation of the electrolyte to float oil and dirt to the surface and an overflow from the far side of the tank for skimming off impurities.

Size of the tank should be such as to accommodate the maximum quantity of material to be cleaned at one time with clearance of 6 in. at sides and bottom. Galvanized iron, brass and aluminum are unsuited for tanks as they are attacked by the alkaline electrolyte.

Operating Methods

Materials cleaned for electroplating should be put in a rinsing tank of clear water or washed with a stream from a hose before placing in the plating bath but soft metals should not be allowed to dry in the air as oxide film will form.

Soft metals, such as alloys of tin, zinc and lead are dissolved slightly by alkaline solutions and this metal is deposited on the cathode surfaces. It is better, therefore, to clean them by direct current, then by reversed current, with 5 sec. finish by direct current. For ferrous metals, direct cleaning is usually used for removing rust and scale. For caked deposits of dirt, the reversed current is used and with 50 amp. per sq. ft. carbon smut can sometimes be removed. Sudden reversal of current has a tendency to loosen inert matter and smut. The finish should be by 5 sec. of direct current to remove the oxygen from the cleaned surfaces.

Cleaning takes from 30 sec. to 3 min. depending on the kind and amount of dirt to be removed.

Steel and iron can best be cleaned by high current density, up to 50 amp. per sq. ft. or more, hence no control is needed. But for non-ferrous metals, which require only 20 to 30 amp. per sq. ft., means should be provided for regulating the amperage. This can be most economically done by controlling the generator voltage, if it supplies only one tank. Where different amperages are required in two or more tanks, the control must be by rheostats in the tank feeder circuits.

For automatic cleaning tanks, where a large volume of work is carried by conveyors through cleaning, rinsing, pickling and neutralizing, surface oil and soap suds, which tend to collect at the ends of the tanks where work lifts out, should be removed by an air blast or by violent agitation so that the work will not become coated as it is removed from the tanks.

Solutions

Essentials for a good electrical cleaning solution are that it be a good electrolyte, free rinsing and with not over ¼ of 1 per cent of anhydrous soap. It must be free from chlorides, sulphates and metal hydroxides and an efficient cleaner for still-tank work, though it may be used at 2/3 the strength required for still-tanks.

Too much soap will result in a film on the anodes, where negative acetic ions become concentrated. Chlorides and sulphates, generally coming from insufficient rinsing after pickling in acid, will corrode the anodes. Compounded cleaners, suited to the dirt to be removed and designed to put into solution quickly oils and dirt are generally more efficient than simple caustic soda, soda ash or tri-sodium phosphate. Concentration of 3 to 5 oz. per gal. is usually about right, depending on the amount of foreign matter to be removed.

This matter is made up of oils, also grinding and polishing compounds in various combinations. To be effective, the cleaner must be able to saponify animal and vegetable oils, emulsify mineral oils and deflocculate carbonized and dried oils. In each case the cleaner should be chosen after study of the foreign matter to be removed but compounded cleaners, suitable for various work, which are likely to be more efficient than ordinary chemicals, can be had from reliable manufacturers. Sodium cyanide and potassium cyanide will increase conductivity and absorb tarnish from non-ferrous metals.

Cornstalk Insulating Board

Manufacture for Heat Insulation*

SOME 80 per cent of the stalks from the corn belt are burned or ploughed under for fertilizer and 20 per cent used as fodder; the value for those purposes may be questionable.

The yield is some 1½ t. per acre. By use of a combined corn picker and stalk cutter, the cost of harvesting the stalks can be brought to some $1.90 an acre, after which they must then be baled. Or a cutter and baler may be used after the ears are harvested. The leaves are not used for board making. Cost for baling and cartage will depend on local wages and the distance hauled, but study of the manufacturing process indicates that value of the stalks standing in the field must be taken at not over 5 per cent of the wholesale price of the completed board, if the process is to be profitable. This wholesale price is fixed by the competition with board made from other materials. When this is known, the value of stalks per acre in the field can be figured and compared with their worth for fodder and fertilizer.

Manufacture of Board

Starting with the baled stalks, the first step is conveying from the storage pile to the mill. Bales are 36 by 18 by 16 in., weight 50 lb. As all stalks must be harvested in a season of 4 to 6 mo., storage for 8 mo. mill supply must be provided. If piled 30 ft. high, this will require some 2600 sq. ft. yard area per ton daily board capacity of the mill, or per 3.3 M. ft. of ½-in. daily board output.

At the mill, unbaled stalks must be run over a magnetic separator on a belt conveyor to remove tramp iron, before passing to the shredder. In the shredding, fibers are reduced to a length of ½ to 1½ in. by machines which use either swing hammers or stationary and revolving pins or knives, or by cutting into short lengths, then passing through revolving knives. This uses some 7.5 hp. per ton an hour capacity.

Water is added to the fiber to give a mixture of

*From a bulletin of the Bureau of Standards, U. S. Dept. of Commerce, by O. R. Sweeney and W. E. Emley.

some 5 per cent fiber and the mass reduced to uniform pulp by a tank beater similar to those used in paper making, by a mill in which loose rods in a revolving cylinder macerate the pulp, or by cooking with 12 lb. water per 1 lb. fiber at 40 lb. steam pressure. When using the beater, the best length of treatment is 3 to 4 hr. A longer time gives stronger board but adds too much to cost; also too long beating gives wet fiber, difficult to form into board while too rapid beating cuts the fiber, giving weak board. The rod mill gave good results but required treatment two or three times to avoid coarse, long-fiber pulp which is difficult to form into board. Cooked pulp gave good results but mechanical beating was selected as commercially preferable.

About half an hour before the finish, sizing is added to the pulp in the beater, 2 per cent of rosin as soda-rosin soap and 5 per cent of alum as a 15 per cent solution of aluminum sulphate in water. These proportions were found to give best economic results as to strength, weight, absorption of water by completed board and cost of product.

Further refinement of pulp is made in a Jordan engine where revolving disks bring fibers into an alined arrangement. Unless stalks are unusually clean, the pulp must be washed to remove dirt. This can be done by a washer on the beater or by screening off surface water as pulp comes from the beaters to the stock tank. There the pulp is diluted to about 1 per cent fiber and goes to the mat-forming machine at 1.5 to 2.5 per cent consistency as may be found to give best results.

Forming the Board

From the stock tank, material is pumped to the mat forming machine. This has a cylinder, divided radially into compartments and revolving with the lower side dipping into a tank. As the arc of a compartment is submerged, an automatic valve applies vacuum in the compartment, drawing pulp against the surface and sucking out the water, so that fiber mats on the outside. After the compartment leaves the tank, vacuum is broken and compressed air admitted, thus loosening the mat, which is delivered onto a belt of paper machine felt of closely woven wires, the successive actions being so timed that a continuous sheet is delivered by the compartments to the felt.

As formed, the mat carries excess of water. Some can be removed by pressure but, if this is too great, dense board of low insulating value results. The pressure is applied by passing the mat held between felts, through several sets of rolls, 5 to 6 being preferred, and drawing off water from behind the rolls to prevent reabsorption. A fine felt is used on top and a coarser one below the mat to allow water to drain away. This also gives one smooth surface that can be used as a finished wall and a rough surface suitable as a base for plastering. Moisture can thus be reduced to 70 per cent and in some cases to 60 per cent. The lower the moisture can be reduced, the less will be the expense of drying.

This is accomplished by passing the board on rolls through a chamber 1100 ft. long. If heated by steam coils to from 200 to 260 deg. F. and with heated air circulation to carry away the moisture, this takes 3½ hr. By using 320 deg. temperature, the time can be cut to 2 1/3 hr. Top rolls to prevent warping have been used but seem hardly to be needed. As kept in stock, the board has 7 to 12 per cent moisture but it is generally necessary to overdry during manufacture.

Board is trimmed to 4 ft. wide by a circular saw and cut into lengths of 4.5 ft. or more as desired. Coating the surface with glue or starch to prevent dusting has been tried but is found unnecessary, if proper freeness of pulp and proper sizing are secured.

Board ½ in. thick is found to weigh 550 to 580 lb. per 1000 sq. ft. Tests have shown that it practically meets the specifications as to strength, expansion and moisture absorption for fiber wall board as given in the Paper Trade Journal for September, 1929.

For heat insulation, the conductivity tested 0.39 B.t.u. per sq. ft. per hr. for a temperature difference of 1 deg. F. per 1 in. thickness. Drying 12 hr. at 212 deg. reduced this conductivity to 0.36 B.t.u., which figures are about the same as for other commercial boards.

Weight of board produced is about 77 per cent that of the bone dry stalks used. The thicker the board of given density, the better the insulation but more stalks are needed and cost of 1000 sq. ft. will be greater. For a given thickness, greater density gives better strength but cost is greater and insulation value less.

Board 2 in. thick, as used for refrigeration insulation can be made in single thickness but varies considerably in weight. Better results have been secured by laminating from ½-in. board, either by cementing layers together with water glass or an adhesive made from corn cobs, or better by wire stitching sheets together, which gives the advantage of an air film between the sheets.

Waterproofing and fireproofing have been tried but add to cost and weight, also decrease insulating value.

Manufacturing Expense

For a plant to produce 46,000 sq. ft. per 24-hr. day, the mill will need 47,250 sq. ft. of floor space and storage pile 35,600 sq. ft., a rather large factory site. Equipment needed would be conveyors for handling stalks, magnetic separator, shredder, four 1-t. beaters, stock tank of 27,000 gal., mat former, board former with press rolls, dryer, cutter, pumps, trucks, motors, shafting and storage for finished board.

Power used would be: For conveyors, 15 hp.; shredder, 25 hp.; beaters, 300 hp.; agitator, 20 hp.; pumps, 30 hp.; mat machine and press rolls 75 hp.; dryer, 60 hp.; cutter, 5 hp.; total 530 hp. Material per day would be 18.5 t. of stalks, 740 lb. of rosin, 1850 lb. of alum and 138,240 gal. of soft water. For drying, about 3 t. of coal a day would be used at 80 per cent efficiency. At prices of board in Ames, Ia., where experiments were carried out, the value of some 36 per cent of product will be required to pay for raw material, power and labor. The rest must cover overhead, fixed charges and profits, if the plant is to succeed. Authors of the bulletin feel that manufacture can be carried on under proper conditions with profit to the manufacturer and the farmer and that understanding of the value of insulating board in dwellings, refrigeration plants, refrigeration cars and the like would result in a market for several times the amount of fiber board now produced.

Second-Hand Condensers Save Expense of New Installation

To avoid the expense of installing new condensing apparatus for a 600-hp. engine, the engineer in charge tried the scheme of attaching a pair of second-hand 300-hp. jet condensers to work in tandem. Each condenser was connected separately to the main exhaust pipe, but the injection water was piped to flow first through one of the machines and then through the other, as indicated in Fig. 1. This arrangement, however, did not work satisfactorily. It was found practically impossible to adjust the gate valves in the two exhaust branches to preserve an approximately even division of the work.

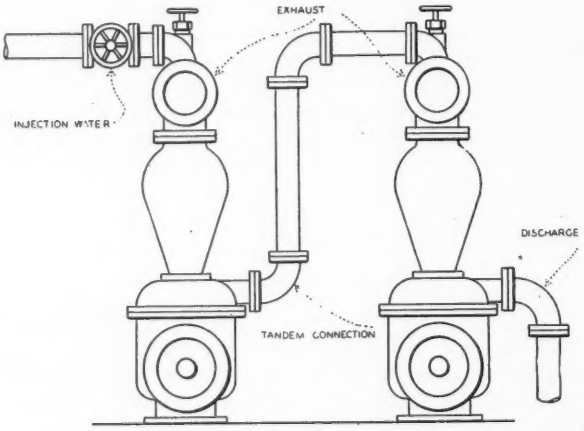


FIG. 1. CONDENSERS CONNECTED IN TANDEM

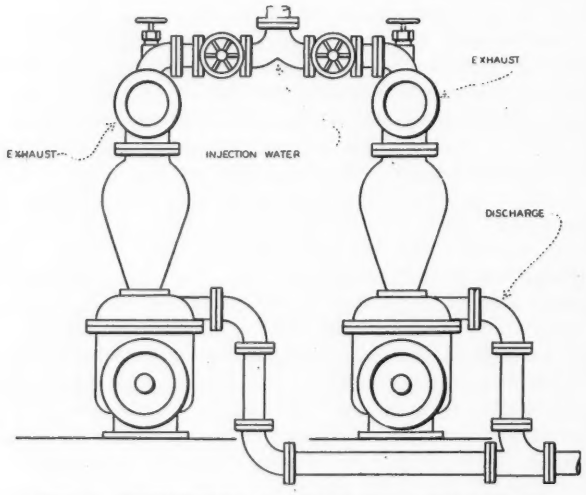


FIG. 2. CONDENSERS DISCHARGING SEPARATELY

The outfit was run in this manner during one summer, but when condensing operation ceased in the fall and the exhaust steam was turned into the heating system, the connections were changed to the form shown in Fig. 2. Here each condenser is connected independently to the injection and discharge lines as well as to the main exhaust header. With this arrangement, the only attention needed was an occasional readjustment of the injection valves.

St. Louis, Mo. D. J. Altizer.

Electrolytic Treatment of Boiler Water

After some 20 yr. study of scale and corrosion, the writer feels that he has learned some things which may be of interest.

Calcium and magnesium form the basis for most scale deposits and these chemical elements are regularly extracted from water for commercial purposes by electrolytic means. I make the statement that the process of integration of scale deposits in steam boilers is a simple combination electrolytic extraction and deposition of these alkaline metallic salts with their natural tendency to come out of solution and stick to metallic surfaces under high temperatures. Boiler operators have overlooked the part electricity has always played in building up scale deposits and in decomposing metallic surfaces in other parts of boilers. Calcium and magnesium are alkaline metals in solution and form one of the most perfect electro-plating electrolytes known.

Any boiler generates thermo-electric currents in proportion to the rate it is forced for making steam. These currents are in proportion to the temperature and bring in their train more and harder scale, corrosion, pitting, deep grooves, foaming and an augmenting of embrittlement. These currents may be measured, controlled and inhibited. If accurately done, results are as follows: In absence of the electro-plating action, sulphate scale is porous and will form only to 1/16 in. thick, when it breaks away from the heating surfaces. Water gets through the pores, which prevents blistering and burning, whereas the electro-plating action fills these pores,

making the scale impervious to moisture, also, the scale adheres firmly to the metal.

Inhibition of currents also stops electrolytic corrosion and pitting and boilers that were notoriously bad foamers have operated with no suspicion of foaming.

In a boiler, some areas act as anodes, some as cathodes, scale being deposited at the cathodic points and pitting occurring at anodic points, which accounts for both scale and corrosion being found in the same boiler. Scale effect may be greater because of the tendency of calcium and magnesium salts to come out of solution at high temperatures.

Embrittlement, as we find it today associated with high boiler outputs, temperatures and pressures, is, to my mind, a question of what part thermo-electric currents play in scale formation and pitting. As we never hear of embrittlement in the center of a solid plate, why does this trouble almost invariably occur at some joint and always under water? Also, why is it associated with sodium in some one of its many forms?

My answer is, the working of a perfect thermo couple which gives off electric currents in proportion to the boiler forcing, these being followed by such results as embrittlement. When currents must pass over a butt-strap joint, proper measurements for electrical conductivity will show that of the joint to be less than of the sodium-laden water. Current passes around the joint from shell to water, then back to the shell so that one side of the joint becomes anodic, disintegrates and begins to show embrittlement. That inside caulking sometimes relieves the trouble and sometimes doesn't is, I believe, because sometimes the caulking is so well done that it makes practically a solid plate of the joint, so far as conductivity is concerned, so that currents no longer pass to the water. If caulking does not create a good, electric path, the current still jumps around the joint. Perfect electrical bonding of all butt-strap joints should stop all embrittlement trouble.

Pacific, Mo. GEORGE S. NEELEY.

(Because Mr. Neeley's ideas differ so radically from those usually held by those who have studied problems of scale formation and embrittlement, his letter was submitted to Professor Frederick G. Straub, whose comments are in substance as follows.—Editors.)

I BELIEVE that there is a possibility of the electrolytic method of prevention of scale and corrosion being put to practical application. Most advocates of this method of treatment, however, let their enthusiasm overcome their strict adherence to facts.

Mr. Neeley states that calcium and magnesium, alkaline metals in solution, form one of the most perfect electro-plating electrolytes known. The electro-plating action has nothing to do with formation of scale. Mr. Neeley infers that scale is formed by a process similar to the electrolytic deposition of metals. There is no basis for such a theory. Electrolytic deposition of metals depend upon the migration of an ion in solution to a pole possessing a different charge, so that the metal being positively charged in solution, will be attracted to the negative pole and plate out.

Scale which forms in a boiler is not the result of the migration of single ions. It is a compound which has come out of solution because of evaporation of water to the point where the density makes part of the salt no longer soluble.

That there are thermo-couples in boilers which generate electrolytic force is supported by no direct evidence, so far as I know. I believe, as already stated, that there is a lot to be learned about electrolytic methods in boiler water treatment. But I do not believe that any of these methods has reached a point of development where it can be applied in actual practice. I have been connected with several plants where such a methods is being used for scale prevention, but, on inquiry at one of these plants, I find that boilers are being turbined regularly and a hard silica scale is being removed at such times.

Urbana, Ill. FREDERICK G. STRAUB.

Isolated Power Plants

POWER APPLICATION from public service utility lines has been increasing rapidly during the last two decades, with a trend to use such service rather than to generate current in isolated plants. Time will work out the survival of the fittest but conservative observers claim to see straws in the wind indicating a return to more frequent use of the service of consulting engineers in making decisions and in planning the layout of plants and building services.

Rendering of this planning service by manufacturer's agents, whose major interest may probably be the amount of equipment which can be conscientiously worked into a layout rather than lowest ultimate operating *economy* cost, has been prevalent for some time in some quarters. Inefficient operation of old isolated plants has discredited them with some owners, who have turned over the layout of plans to architects. These in turn, knowing little of the requirements for mechanical equipment of buildings, allow an agent who sells say heating equipment to lay out the heating system and even to write the specifications covering it, no charge being made for that service. As the heating equipment sells no high-pressure boilers, engines, turbines or generators, the public service salesman has an opening to sell its service to the owner. Certainly there are cases where the isolated plant is less desirable than utility supply but the heating equipment and public service salesmen are hardly the ones to decide that point intelligently and fairly.

Such decision, to insure most economical operation and supply of power, light and heat, should be made by a trained, experienced and unbiased engineer. The main problem is to sell that idea to the owner after an architect has been employed, as an engineering fee must be added and often the architect is already sold on the advantages of public utility supply.

In one field, hotels, many of the largest have heating service and public utility electric supply. Engineering analysis would have demonstrated that for a 300-room hotel with, say, 15,000 sq. ft. of heating surface, modern steam laundry, kitchen and service room, steam tables and the like, the steam needed for these and for heating water would easily make the electric current needed for the building. About $8000 would cover the cost of an independent power plant.

Argument that omitting the power plant will add a few more rooms is of little account since most hotels,

from the start, operate at 65 to 80 per cent occupied.

For 5000 degree-days of heating season, with coal of 12,000 B.t.u. heat value and system at 50 per cent efficiency, electricity can be made at a cost of 1½c per kw-hr. This would amount to about $2500 a year. Current would otherwise be paid for to the utility company at probably higher cost.

The engineer's position is that it should require but little figuring on a fair basis to show the owner whether or not it will be more profitable to invest in a power plant or in empty rooms and it is well worth the owner's while to be certain on this point before making a decision.

Dallas, Texas. J. P. GREENWOOD.
Consulting Engineer.

Erecting Ammonia Pipe

IN ERECTING ammonia pipe, it is necessary to do a good job, for ammonia will leak through a joint that would hold steam, oil or water. Pipe and fittings must be of first class material and workmanship and of necessary strength. Extra heavy pipe and fittings are almost always used.

It is best to buy new dies to cut pipe threads if many threaded joints are to be made, as all threads must be clean cut. Ragged or broken threads will not allow a smooth clean fit between the pipe and fittings.

After threads are cut, they should be washed with gasoline to remove all cutting oils as litharge and glycerin will not harden if oil is present. The threads in the pipe fitting should also be washed with gasoline and both threads should be brushed with a fairly stiff and not too coarse wire brush to remove all dirt.

The pipe should be held at an angle and pounded to remove all dirt, rust and scale. Never use dirty pipe or fittings, as the dirt will clog the suction strainer of the compressor, is liable to get into the oil in splash systems and cause hot bearings and, by lodging on the valve seats, may cause the valves in the system to leak.

In making up joints, most erecting men use litharge and glycerin; however I use a manufactured pipe fitting compound which comes in a rather stiff liquid form, easy to handle and which does not set rapidly like litharge and glycerin. But no matter what pipe joint compound is used, the threads must be clean.

Never put pipe dope on the threads inside a fitting, as it is liable to be forced off the threads in making up the joint and lodge somewhere in the system where it will cause trouble. Put the pipe dope on the pipe threads and use only enough to make a tight neat joint.

After the job is finished, all work should be tested for leaks with a pressure of not less than 350 lb. The system may never be required to handle so high a pressure in regular work but may approach it at times when it becomes necessary to pump all or most of the ammonia to one or the other side of the system to do repair work.

Chelan Falls, Wash. C. M. DAVID.

Repairing a Steel Tape

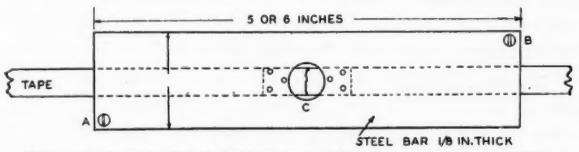
STEEL TAPE lines are used by most power plant engineers to secure accurate measurements. Such tape lines, however, are easily broken; hence the method I use to repair them may be of value to other engineers. This is as follows:

Procure two pieces of flat iron bar, 1½ in. wide and about 5 or 6 in. long and ⅛ in. thick. Drill a hole about ⅝ in. in diameter in one of the pieces as indicated at C in the accompanying sketch. Also drill small bolt holes in both pieces and at opposite ends of the bars as shown at AB.

Having drilled these holes, now clamp the two pieces together by passing bolts through the holes AB and drill the six small holes at the center.

Next, loosen up the bolts and set the ends of the broken tape between them; the hole at C will make it possible to place the two ends together accurately. Now tighten up the bolts at AB.

Using a hard steel flat end punch (the round end of a broken twist drill ground flat will do) punch three



DEVICE USED IN MENDING A BROKEN STEEL TAPE

holes in each end of the broken tape, using the punch through the small holes. The holes will be cut clean with no burr and the tape will not crack.

Remove the tape and prepare two pieces of extremely thin steel or hard brass about 2 or 3 in. long by setting them between the irons, clamping the irons together and then punching the 6 small holes. Use one of these pieces on each side of the broken tape—and rivet all together. The result is a perfect flexible splice which will roll up in the case.

If only one piece of steel or brass is used on one side only of the broken tape, the tape is liable to break again at the rivets; when the two pieces are used, such a break will never occur.

There are many steel tapes unused at present because there is one or more breaks along their length. The simple procedure here described will enable anyone to make good repair splices in a few minutes with the use of the drilled irons.

Toronto, Canada. JAMES THORN.

TOTAL PRODUCTION of soft coal during the week ended June 27, including lignite and coal coked at the mines, is estimated at 6,742,000 net tons. Compared with the output in the preceding week this is an increase of 107,000 tons or 1.6 per cent. Production during the week in 1930 corresponding with that of June 27 amounted to 7,995,000 tons.

Total production of Pennsylvania anthracite during the week ended June 27 is estimated at 1,262,000 net tons, an increase of 312,000 t. or 32.8 per cent over the output in the preceding week. Production during the week in 1930 corresponding with that of June 27 amounted to 1,423,000 t.

Consumption of coal by public utility power plants in the United States as reported by the United States Geological Survey for 986 plants was 2,954,924 net tons in May, 1931, as compared with 3,294,216 t. in May, 1930, a decrease of 10.3 per cent.

Collector Ring Trouble on Diesel Engine Generator

WE HAVE IN SERVICE a 235-kv-a. a.c. generator, 220-v., 3-phase, 565-amp., 60-cycle, with a revolving field. This field is excited by 125-v., 68-amp. exciter, chain driven from generator shaft. The direct current from exciter passes through four brushes set against collector rings on the generator shaft to excite field coils. There are 2 rings and 2 brushes against each ring, the ring nearest the exciter, pits considerably at a point where the ring stops. This generator is driven by a Diesel engine and, of course, when the engine stops it balances itself on the quarter, which always stops the ring against the brush in the same place. Why doesn't the other ring pit and burn? What causes this pitting in the first place, as there is no current present when it starts or stops and it doesn't heat up? Of course, each time it passes the spot arcing occurs, but what causes the original pit and what can I do to avoid it? I stone the spots smooth with a commutator stone, but inside of a week the two spots and the arc appear again. C. G. H.

What Causes Excessive Heating in Generator?

WE HAVE A 140-kv-a. alternating current generator, 250 v., 323 amp. per terminal, 3-phase, 60-cycle, 720-r.p.m., driven by a 16 by 20-in. engine and excited by a belt driven exciter unit rated at 6 kw., 125 v., 48 amp.

When starting up, we carry 400 amp., 220 v. but the generator soon heats up and the voltage drops, so we have to decrease the load to 250 amp. in order to hold the voltage to 220 v. What is the trouble? The generator was bought secondhand. With the steam pressure at 110 lb. gage the engine seems to maintain the speed until the generator starts to heat up; then it slows down until the load on the generator is relieved. H. V. D.

A. The trouble which you are having with this generator in our opinion is due to overloading caused by low power factor. While you do not state anything in regard to the power factor, it is quite evident from even a few simple calculations that unless the power factor of your load is unity, the generator will be overloaded.

You state that the machine is rated at 250 v., 323 amp. per terminal. The kw. output of this machine, therefore, will be $250 \times 323 \times 1.73 = 139.69$, or roughly, 140 kw. This also according to your description is the kv-a. rating of the machine; therefore, since power factor equals kw. divided by kv-a., the rating of your machine is based on a power factor of one.

In starting, you state that you carry 400 amp. at 220 v. The kw. output of the machine under these conditions is $400 \times 220 \times 1.73$, or 152 kw. Thus, even at unity power factor your machine will be overloaded.

If, however, instead of unity power factor, we assume that the power factor of your load is 0.8, which is entirely possible, the kv-a. output of the machine is 152 divided by 0.8 or 190 kv-a., or assuming that the machine is operated at 140 kw., at 0.8 power factor the machine will still be carrying 140 divided by 0.8 or 175 kv-a.

It is evident, therefore, that the machine is heating up due to carrying too much load and we suggest that the first thing you do is to measure accurately the power factor of the system when the machine is operating under the conditions you specify in your letter. If the power factor is found to be less than unity, it is quite certain that the machine is too small for the load under these conditions and that you must either provide a larger machine or raise the power factor to unity.

Pipe Expansion

IN ERECTING a long steam line that will have a variation in temperature of 320 deg. F., how far apart should the expansion joints be placed, if each joint can take care of a motion of 3 in.? F. V. G.

A. For wrought steel the co-efficient of expansion is 0.000,007,5. This varies somewhat with the temperature but the value given is safe for the temperatures at which you are working. This co-efficient is the expansion per unit of length per degree rise in temperature. The total expansion for any given length would therefore be this co-efficient, K, times the length, times the temperature rise, or, as an equation: $KLT = 3$, for the case given.

Solving this for L we get that: $L = 3 \div (0.000,007,5 \times 320)$, which gives a value for L of 1250 in. as the length which would have an expansion of 3 in. This is 104 ft. and would mean that expansion joints should be placed approximately every 104 ft.

Practice of Draining Superheater

AT WHAT pressure would you drain a superheater? W. R.

A. The practice of flooding superheaters in starting a boiler has been practically abandoned as unnecessary and objectionable. When a boiler is started up, the drip valve in the superheated steam header is left open and the boiler tubes absorb the heat of the gases so fast that when they reach the superheater, they are sufficiently cool and the first steam generated protects the superheater without resorting to flooding.

Editorial Comment

Stepping Out

In the colloquial parlance of the day this implies getting out of routine, putting on up-to-date dress and doing things. It indicates the will, translated into action, to do different things or to do old things in a new way; to change habits and view point so as to get more out of life.

Right now, stepping out mentally by the individual and mechanically by the plant is much in order. Conditions are changing. Lower costs, more and better product are needed to meet competition and encourage sales. The plant executive and engineer need the will to find and adopt improved methods and to install new machinery where they will help to better results. Nothing was ever yet so well done that it couldn't be done better, if the way could be discovered.

Each plant will have individual problems which call for special study but some general types of improvement are applicable to nearly all plants.

Power factor and load factor are always with us. If load is variable so that induction motors run lightly loaded much of the time, the synchronous motor is a means to step out to better power factor. Instances are pump drives, flour mill machinery, fan drives. Grouping machines on one motor or, on the other hand, providing individual drive which will be shut down when machines are not in use will help the load factor. One example is a group drive with 164 large bearings and 3600 ft. of belting replaced by direct drive having 20 small bearings, with maintenance reduced from 65 cents to 12 cents per ton of product. In a furniture factory, change from line shafts to individual drive paid, even though it was a moderate-sized plant.

Automatic control is proving valuable in steadying operation and reducing trouble. Bad motor starting caused bearing trouble which was overcome by a magnetic starter. In a textile mill magnetic starter switches and time-delay push button stations have increased productiveness, economy and safety as well as preventing 96 per cent of shut-downs due to momentary dips of voltage. Remote control of service cars has reduced labor cost in one rock quarry and organized car movement to meet load requirements. The Thyratron tube is controlling speeds and production in numerous ways. Air for blast furnaces is being weighed by automatic gates, with large savings in the coke required. Automatic control of heat treating by use of an electric conveyor furnace reduced handling costs 60 per cent, tripled production, improved the product and lowered maintenance cost. Use of electric heating permits accurate control to improve product in many cases.

Welding for construction and repair work is helping many plants to step away from costly methods and delays which eat up profits. Very thin plates to huge pieces, also metals and alloys thought unwelded are now being handled by new equipment. Multiple and automatic welding sets are speeding fabrication by standardized methods which give dependable results.

Is your plant stepping out as it should? Have power factor, type of drive, speed control, automatic control, manufacturing methods been studied with a view to modernizing equipment for economy? With the present keen competition, stagnation is a handicap that will be difficult to overcome.

Back-Seat Driving

"Criticism of modern society may somewhat tritely be called the back-seat driving of progressing civilization," says Thomas T. Read, writing on Our Mediaeval Minds in the current Atlantic Monthly. He goes on to point out that while sound criticism is helpful, captious faultfinding is annoying and unsound criticism is positively detrimental as it leads to incorrect action. Criticism that confuses mechanisms with the uses made of them retards progress in another way, because it is an unwarranted derogation of those workers who have made noteworthy progress in what they were called upon to do. Criticism of this type, Mr. Read points out, is typical of the mediaeval mind which ignores or evades facts, especially if they seem to involve relinquishing anything already accepted.

"Scientists and engineers," he goes on, "naturally resent as irrational and unintelligent the implication in much current criticism of society that the use of improved facilities for ends that are unworthy or perhaps even harmful is in some vague way their fault. This inference is detrimental in that it annoys workers who have been doing their tasks well but it is chiefly harmful in that it deflects attention from the real deficiency, that those who should be finding worthier things for human beings to do have not been equal to their responsibility."

Every engineer has encountered at some time in his career exactly this type of criticism offered by what Mr. Read calls the mediaeval mind. Just why so many people have this type of mind is not quite clear but the fact remains that the persistence of mediaeval thinking in a modern world is detrimental to progress and makes itself felt in many questions affecting the whole people. Such thinking naturally leads to a confusion of mechanisms with the uses made of them and tends to form in the mind of the general public an entirely incorrect idea of what the scientists and engineers are doing at present and their general objectives for the future.

Mr. Read asks what, if anything, should be done about it? It would seem that the engineering profession as a unit, acting through its various professional societies, is in a position to do a great deal about it.

Many people with this mediaeval type of mind are blaming the engineer because in some way the industrial system which he has been so instrumental in building up has got out of gear. The fact of the matter is that all that the engineer has done is to provide the tools by which the system could be built up and he has had

very little to say on the subject of whether those tools were being put to proper uses or not. The tools themselves are neither right or wrong, good or bad. Surely it is not the fault of the engineer if, for example, after creating the automobile and the highway on which it can be used, it is found that occasionally a bank robber or bandit can employ that automobile and that highway in committing a crime.

Certainly the question may be raised as to whether anybody in particular is to blame for such a situation. It may be merely one of the phenomena of an engineering civilization with which we have to cope. As long as the mediaeval type of thinking persists, however, as it does among too large a proportion of our population, it would seem that the engineer, with means at hand to combat it, should no longer remain silent.

If the engineer is to be commanded to function for the benefit of society, it is obviously unfair for society to turn on him with reproach when some of its members misuse the tools that he has provided. A definite campaign on the part of the engineering profession to place this thought vigorously and continuously before the public would do much to counteract the annoyance to individual engineers of having to waste their energies in rebuttal of this needless criticism, which, unfortunately leads to wrong courses of action to the detriment of everybody.

An Accomplishment

In 1920, the engineering world was shaken with the pulverized coal vs. stokers controversy with odds favoring the stokers. Late in that year Lakeside station was put in service burning pulverized fuel exclusively. A few months' operation and other pulverized fuel stations were planned and the odds began to shift slightly. Time went on and the controversy was allowed to die by common consent.

Radiant superheaters were developed and applied to Lakeside with the result that about 1500 B.t.u. per kw.-hr. were lopped off the heat rate. Changes were made, round tube elements being substituted for the old time flat-faced cast and forged elements. The controversy was not as spirited as with pulverized coal but progress was steady and they are now widely used with their field of usefulness steadily increasing.

High pressures came into the picture. Lakeside early adopted 1200-lb. turbines superimposed on the existing cycle. Again they departed from the beaten path and used a bent tube boiler. Not bent tube boilers but a single bent tube boiler for each high-pressure turbine unit, each boiler complete with convection and radiant reheating and superheating surfaces so proportioned that steam temperatures were controlled over the entire range of quarter to full load without complicated equipment.

Those are but three of the developments that have kept Lakeside Station in the spot light for over a decade. Started in 1920 with a planned ultimate 200,000 kw. capacity, the station was completed in 1931 with a capacity of over 310,000 kw. From a heat rate of 21,000 B.t.u. per kw.-hr. in 1920, steady reductions have taken place until today it is about 13,500.

Costs have been low, operation records, especially for high-pressure boilers, have been phenomenal and the practical research work carried on has been of great assistance to the industry. Now completed to ultimate capacity, Lakeside starts the second decade of operation with a record for progress which will probably never be equalled.

This Changing World

As we look over a modern high-pressure reheat station it is hard to realize that reheat practice in this country is but seven or eight years old. In fact, the first stations to use reheat are still in service, considered as some of the leading stations of the country.

In those few years, over a score of reheat stations have been put into service at pressures ranging from 600 to 1800 lb. In a table on another page of this issue are listed 22 such stations, two of them being industrial plants built to serve a single large factory.

Such rapid changes are hard to visualize. If it were not for the printed descriptions of power plants completed in the post war years of 1920 and 1921, it would be impossible to convince the modern power plant engineer that such primitive stations were built but 10 or 12 yr. ago by leaders of the electric light and power industry as well as by industrial companies.

This is a short period of time as power plant life is considered. Engineers are prone to neglect this obsolescence factor and base depreciation on a life of 15 or 20 yr. This being true, it is obvious that there are many plants operating in this country that are in good shape mechanically but sadly out of date.

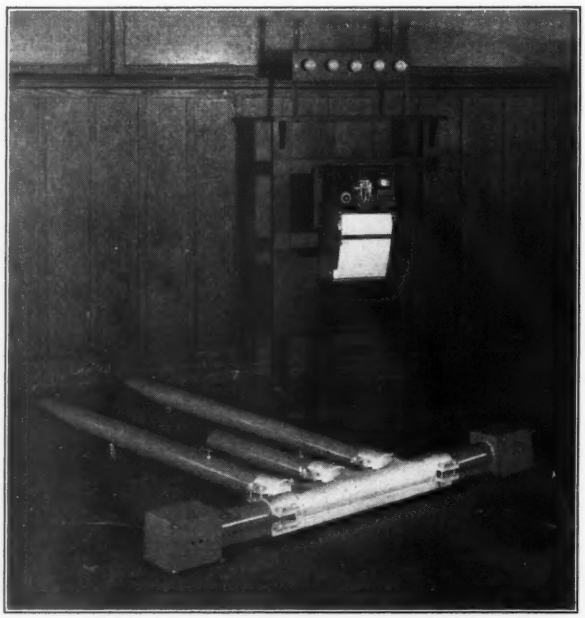
Sometimes an entire new plant is the only answer, more often, however, a little thought will show how new developments can be applied to the existing equipment with but little expense. To read about these improvements is fascinating yet if an engineer cannot answer his own question, "Could that be applied to my own plant?" he is not doing justice to his position. To feel that wishing to have a part in each new development is like reaching for the moon is detrimental to progress. Your plant may be just the one where an improvement would fit in nicely and even though you definitely determine that it will not, the attempt has been well worth while because the analysis will give you an insight and knowledge of your plant that will suggest other changes to improve its efficiency.

Discussing the interesting fact that the same word may have different connotations for different people and the way in which this militates against complete understanding between people, an editorial in the Stone & Webster Journal points out that in many cases education seems only to widen the breach. An amusing illustration of this point is given in the story of a woman, the head of a school for girls in India, who had occasion to hire a native plumber to do some work for her. The man would work for a few minutes, then drop his tools and ask her what to do next. Finally she became exasperated and exclaimed, "Goodheavens, man, use your common sense!" The plumber looked at her with an injured air and replied, "But, madam, I have only a technical education." If the reader is disposed to draw any conclusions from this remark, this seems to be a good season of the year for the drawing of conclusions.

Power Plant Engineering Developments and News

Smoke Recorder

FOR DETERMINATION and recording of smoke in flues and stacks, the L. & N. Smoke Recorder has recently been placed on the market by Leeds & Northrup Co., Philadelphia, Pa. The device consists of a measuring chamber at the breeching or stack, a recorder at any convenient point and an indicator at the boiler.



L. & N. SMOKE RECORDER, SHOWING SAMPLING TUBES AND MEASURING CHAMBER ON FLOOR, RECORDER AND SIGNAL LIGHTS

The measuring chamber through which passes the smoke drawn in through the sampling system contains a lamp at one end and a special temperature-compensated thermopile at the other. Heat radiated from the lamp passes through the smoke-filled chamber and falls on the thermopile. With a constant heat source in the lamp, the amount of heat falling on the thermopile is inversely proportional to the density of the smoke. The heat from the lamp that reaches the thermopile causes the latter to generate a voltage and the measurement of this voltage is the measure of the smoke density.

The recorder is the standard L. & N. potentiometer recorder. It measures the voltage of the thermopile and reads direct in per cent smoke density or Ringelmann chart numbers. The boiler room indicator is a bank of five lamps. The color of the lamp burning tells the fireman the smoke condition.

The three tubes of the sampling system extend into the stack or breeching. An aspirator in the center tube, working at about 4 lb. air pressure, causes flue gas to flow into the two outside tubes, around the bends and out of the center tube back into the stack. Careful design of the curves in the sampling system to reduce eddy currents, and the position of the lamp and thermopile, about two feet away from the sampling stream, prevent dust and soot from collecting on the glass covers which are placed in front of the lamp and thermopile.

Tendency for dust to pile up in the tube between the lamp and thermopile is minimized by admitting air through several small holes in the bottom of the tube. Air currents, thus created, keep the dust moving and it is withdrawn from the system by the aspirator. In spite of this, after a long period of time, there is a slight piling up of dust which cuts down the light intensity; however, by shutting off the aspirator until the system is clear of smoke and adjusting a rheostat in the control box to make the recorder read zero smoke density, the apparatus will function normally. Cleaning is necessary only at infrequent intervals, it is stated, and is then simply and easily done.

Temperature Compensator for Fluid Meter

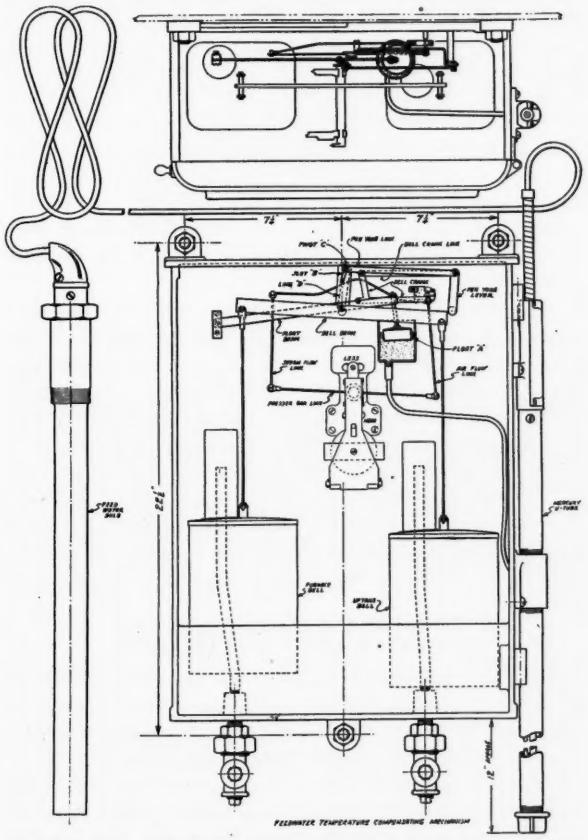
WHEN METERING feedwater to boiler, a change in water temperature of 50 deg. F. may cause approximately 1 per cent error in the meter reading. To compensate for this error in Bailey meters, the method shown has been developed. The compensating mechanisms consist of a temperature measuring device and a system of linkage which corrects both the flow pen and the flow integrator for variations in the specific volume which the feedwater undergoes during changes in temperature.

The temperature measuring device consists of a temperature bulb installed in the feedwater line and a mercury U-tube attached to the fluid meter. These two elements are connected by a copper capillary and the entire system, consisting of temperature bulb, capillary and U-tube is charged with nitrogen gas at low pressure.

One end of the U-tube terminates in a reservoir in which the mercury rises and falls in accordance with the variation of gas pressure in the system. This pressure is a function of the gas temperature, which in turn depends upon the temperature of the water surrounding

the temperature bulb. A small float rests on the surface of the mercury in the reservoir and serves to operate the compensator linkage, which by means of the compensator cam, corrects both the flow indicator and the flow pen for changes the feedwater temperature. This type of compensating mechanism can be applied, it is stated, to the measurement of steam and also to the measurement of gas or air.

In cases where variation in feedwater temperature reaches a considerable magnitude, it may be desirable to compensate the air flow mechanism of the Bailey boiler meter to maintain the correct relation between steam flow and air flow. Any variation in feedwater temperature varies the amount of heat absorbed in evaporating a pound of water. Since steam flow is used in the measure of the heat absorbed by the boiler, any variation caused by changes in feedwater temperature is not recorded by the steam flow pen of the meter. By the proper compensation of the air flow mechanism, the correct relation of heat absorbed to air supplied for combustion can be maintained.

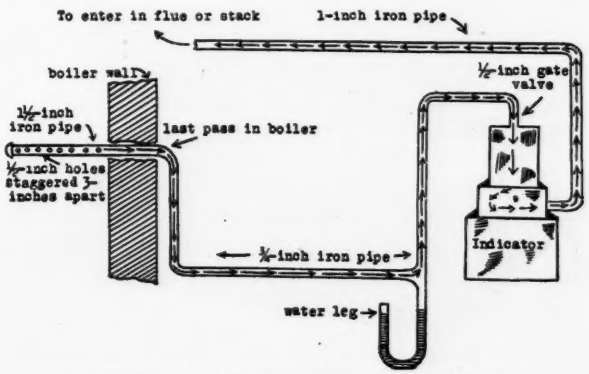


FEEDWATER TEMPERATURE COMPENSATOR ON BAILEY BOILER METER

A method by which this compensator is applied to a boiler meter is shown. A standard air flow mechanism, consisting of furnace bell, uptake bell, and bell beam, is used to measure the actual air flow to the furnace. In addition to this, a feedwater temperature measuring device, consisting of a bulb for installation in the feedwater line, connecting capillary and a mercury U-tube with an open reservoir for the float, is attached to the meter. In operation the float A rises and falls with changes in feedwater temperature; through a suitable linkage the motion of this float is transposed upon the motion of the normal air flow mechanism to give a resultant motion that takes count of the temperature. The motion of the air flow pen is then transmitted suitably so that the electrical impulses produced by the steam-flow air-flow contactor for more or less are likewise compensated for changes in feedwater temperature. Both these devices are recent developments of the Bailey Meter Co., Cleveland, O.

Smoke Indicator

HANNIGAN-McPHERSON Smoke Indicator designed for installation in boiler rooms to enable the boiler operator to observe the condition of the gases and smoke leaving the boiler, has recently been placed on the market. The indicator, it is stated, is applicable not only to boilers but to any processes where it is desired to observe gases and vapors either as the only observation or as a check on other observations. One of the principal features claimed by the manufacturers is that its action is so simple and direct that the time lag between the occurrence of the condition causing smoke and the actual indication of these conditions is practically eliminated.



METHOD OF CONNECTING SMOKE INDICATOR

As shown, the inlet is connected to the last pass of the boiler, while the outlet is connected to the stack. A suction fan is located in the lower part of the body of the indicator and is designed to draw a continuous sample of smoke and gas from the last pass through the top chamber of the indicator, discharging it into the stack. The top chamber has a hinged clear glass front door and a lighted background to enable the operator to see what passes through this chamber. The new indicator is a product of C. D. McPherson, 5010 Duffield St., Frankford, Philadelphia, Pa.

THE LARGEST HIGH-VOLTAGE, high-amperage, mercury-arc rectifiers now in commercial service are the 3000-v., 3000-kw. (1000-amp.) units supplied by the General Electric Co. for the electrification of the Delaware, Lackawanna and Western Railroad in New Jersey. The maximum current-carrying capacity today is represented by the 24-anode, 10,000-amp. (continuous rated), 625-v. rectifier for an electrolytic plant. A 12-anode rectifier now being built at Schenectady for railroad service will handle 14,400 amp. at 625 v. for one minute. All of these have subdivided anode arms.

Type QR Pump and Receiver

TYPE QR PUMP and receiver recently placed on the market and shown in the accompanying illustration is designed to operate at any pressure from 0 to 100 lb.; it is intended to be used if high pressures must be maintained constantly or if there is a wide variation and the pressure is carried.

Units consist of the type Q pump (as described in the September 15, 1930 issue of Power Plant Engineering), the receiver tank, the drip pan and the automatic control.

A self-cleaning suction strainer is placed in the pipe connecting receiver to pump to prevent any scale from entering the pump. The receiver tank, of steel plate with all seams and joints welded steam and water tight, is furnished with a clean-out opening at the end, with flange opening for the return line, and with vent and

TYPE QR PUMP AND RECEIVER SHOWING AUTOMATIC CONTROL

water gage glass. It is mounted on two cast iron saddles or legs that can be furnished either 12 or 3 in. high as desired.

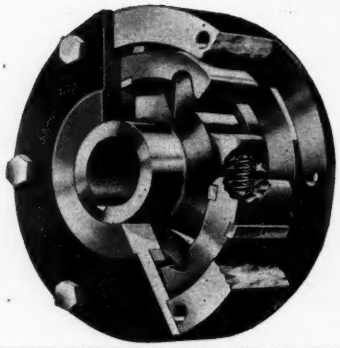
Automatic control is accomplished by a copper ball float in the tank connected to the motor, as shown, by suitable leverage. Rising and falling of this float with the water level starts and stops the motor driving the pump.

The type QR pump and receiver is supplied in capacities ranging between 6 and 75 g.p.m. for amounts of radiation up to 15,000 to 25,000 sq. ft. It is a recent product of the American Steam Pump Co., Battle Creek, Mich.

One-way Clutch

DESIGNED to be an instantaneous, positive and non-slip clutch, the Pitter one-way clutch as shown in the illustration has recently been placed on the market. It consists, as shown, of a steel shoe with alloy steel contact inserts, case hardened and ground for locking with inner and outer races, a forged steel hub, an inner steel race case hardened and ground, an outer steel race case hardened and ground, steel springs to insure position of shoe and take up wear and steel struts case hardened and ground.

When the outer case is rotated with respect to the inner one, the clutch is designed to lock automatically on the final movement forward and with the slightest movement in reverse, to prevent any reversing action even to a thousandth of an inch, it is claimed. The clutch is designed so that no part can jam and so that power applied in the forward direction will instantly release the pressure of the shoes against the inner and outer races of the clutch to make the motion smooth and instantaneous.



CROSS-SECTION SHOWING THE SIX PARTS OF THE PITTER ONE-WAY CLUTCH

The Pitter clutch is designed with large surface contact so that there are no line or point contacts to wear away rapidly or score the races. The clutch is designed to be applied, if desired, for converting alternating motion into one-way movement and is suggested for use on such equipment as agitators, heaters, ash handlers, stokers, compressors, dryers, hoists, lubricators, pulverizers, ratchet feeds, reducers and similar application. It is made by Universal Gear Corp., Chicago, Ill., for maximum torque of from 204 lb. in the smaller sizes to 124,800 lb. in the larger sizes.

E-Z Wire Stripper

FOR RAPID stripping of finer types of insulated wire, used on electrical appliances from 12 gage to the finest magnet wire, the E-Z Wire Stripper or tool has been placed on the market by Ideal Commutator Dresser Co., Sycamore, Ill. It has open side feed, and is designed for stripping stranded, solid core or parallel cord with a single pedal movement, also for end or center stripping on single or duplex cord. A single pedal movement is intended to grip the wire, cut the insulation and strip it, all three operations being automatic. Bench space is 8 by 12 in., floor space 18 by 18 in., weight 25 lb.

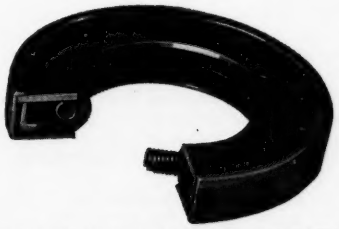
NEW TYPE of pressed steel Texrope sheave to meet the demand for a light weight, low priced drive, has been developed by Allis-Chalmers Manufacturing Co., Milwaukee, Wis., and complete Texsteel Texrope Drives are available from stock for immediate delivery.

Texsteel sheaves are die pressed from extremely tough steel and then each section is welded both at the web and at the rim to eliminate vibration and noise and to give an accurate balance for true running. They are manufactured in a large range of diameters, permitting ratios as high as 6:1. They are painted with aluminum paint to protect them and to give them a pleasing appearance.

Oil and Grease Retainers

MANUFACTURED by the Chicago Rawhide Manufacturing Co., 1301 Elston Ave., Chicago, Ill., the Perfect Oil Retainer is a self-contained, self-alining devise successfully used for sealing lubricants and protecting bearings from dust, dirt, grit and other abrasives in all machinery applications where oil or grease is used.

Most notable features of the Perfect Oil Retainer are its leather packing member which has a background of more than 50 yr. of industrial experience and the correctly designed coil spring which was developed after extensive experiments with all types of spring construction. This spring is designed and so placed in the unit so as to exert a uniform, positive pressure, holding the packing to the surface and forming an efficient seal.



PERFECT OIL RETAINER OF THE CHICAGO RAWHIDE MFG. CO.

A locking device positively prevents rotation of the packing member within the assembly.

Special tannages of leather are selected to meet various conditions under which the retainer must operate such as extreme heat or high speeds. Perfect Oil Retainers are supplied as a self-contained, compact unit and are installed by a simple press fitting operation into a simple machine recess in hub, housing or bearing retainer.

Death of Truman P. Gaylord

TRUMAN P. GAYLORD, 60, vice president of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., died suddenly on July 5 in Shelby, Michigan, his boyhood home, where he had been visiting his mother. Mr. Gaylord was born in Shelby. He attended the Allen Academy of Chicago; the University of Michigan, from which he was graduated with the degree of electrical engineer; and Armour Institute of Technology, from which he secured a degree in 1895.

The Chicago World's Fair was starting when Mr. Gaylord began to work for the Fair Co. as engineer of the Underground Construction and he continued in that capacity from 1892 to 1893. At the close of the World's Fair, Mr. Gaylord became assistant professor of electrical engineering at Armour Institute of Technology, Chicago, serving there from 1893 to 1898. He was associated with the Commonwealth Edison Co. from 1898 to 1899, when he entered the employ of the Westinghouse Electric and Manufacturing Co. He was appointed district manager of the Westinghouse Co.'s Chicago office in 1902, the position he occupied until he was made acting vice president in August, 1914. He was elected vice president in April, 1929.

Mr. Gaylord was elected to directorship in the Pittsburgh Chamber of Commerce in 1926, and in 1927 was chosen president of that organization, an office he held until 1929. He was a member of the American Institute of Electrical Engineers, the Chamber of Commerce of the United States, the Duquesne Club of Pittsburgh and the Pittsburgh Athletic Club.

News Notes

U. S. HAME Co. of Buffalo announces that it has purchased the assets of both the Lawson Mfg. Co. of Cleveland, Ohio, and the Warner Hammer Co. of Cromwell, Conn.

The Lawson Co. manufactured the Laswon wrench known to the hardware, mechanical and plumbing trade as the wrench with the angle handle. This wrench has a wide reputation as an efficient pipe wrench for difficult work; due to the angle design of the handle it can be used in the most awkward corners, close to walls, floors or ceilings. The Engineering Department of the U. S. Hame Co. has added refinements in design, construction and finish. Drop forgings of special alloy steel have been specified for the wrench, which will be marketed under the name of USHCO Lawson Wrench.

Warner hammers and chisels will be branded as USHCO Warner tools.

The officers of the U. S. Hame Co. are: R. P. Carr, president; J. M. Glaser, vice-president; T. W. Porter, vice-president; R. W. Southard, secretary; R. U. Carr, treasurer.

Sales activities on these lines will be under the direction of T. W. Porter, vice-president in charge of sales. Robert H. Blockall will continue in charge of the Railroad Equipment Division, and the general trade will be reached by the U. S. Hame Co. sales force, assisted by manufacturers' agents, who will be appointed to cover various well-defined territories.

ELLISON DRAFT GAGE Co., Chicago, Ill., announces the appointment of L. Wharton-Bickley, Bailey Building, Philadelphia, Pa., as its exclusive representative in eastern Pennsylvania and southern New Jersey.

NEW SERIES of small Herringbone-Maag Speed Reducers has just been developed by the W. A. Jones Foundry & Machine Co., Chicago, Ill. Capacities range up to 18 hp. Reduction ratios are from 12 to 1 up to 48 to 1. The smallest reducer in this series is 20 5/16 inches long and 14¼ inches high. The base measures 10¼ inches wide. For universal application all the reducers in this series have high and low speed shaft extensions on both sides to eliminate the need of a right or left hand assembly. Two shaft guards are provided.

M. C. TERRY has been appointed chief refrigeration engineer of the Westinghouse Electric and Manufacturing Co. with headquarters at East Springfield, Mass., it was announced by R. S. Feicht, director of engineering for the company. The announcement states that J. H. Ashbaugh, assistant manager of the refrigeration engineering department, will be in executive charge of that department.

THE ELLISON DRAFT GAGE Co. of Chicago announces the appointment of the Hauer Power Equipment Co., Union Trust Building, Cincinnati, as its exclusive representative in the Cincinnati and southwestern Ohio territory.

VOTERS OF Lenox, Iowa, under authority of recently enacted legislation, which permits construction of power plants to be paid out of prospective earnings, authorized construction of such utilities in Lenox at a cost not to exceed $100,000. The town had previously been supplied with power by the Iowa Southern Utilities Co.

UNITED STATES CIVIL SERVICE COMMISSION announces open competitive examinations for associate engineer (optional branches—aerial navigation, aeronautical, construction, heating and ventilating, and telephone and telegraph engineering) and assistant engineer (optional branches—heating and ventilating, and construction engineering) applicants for which must be on file with the United States Civil Service Commission, Washington, D. C., not later than August 21, 1931. The examination is to fill vacancies in various services, for duty in Washington, D. C., or in the field. Entrance salaries for associate engineer range from $3200 to $3800 a year and for assistant engineer from $2600 to $3200 a year. Competitors will not be required to report for examination at any place, but will be rated on their education, training and experience. Applicants must have completed at least two full years of an acceptable engineering course. Certain specified additional education or experience are required. Full information may be obtained from the secretary of the board of examiners at the post office or customhouse in any city or from the Commission at Washington, D. C.

PEABODY ENGINEERING CORP. of New York announces that O. Milne, chief engineer of Peabody, Ltd., has just returned from its London office where he has been just a little over a year, studying foreign conditions. After spending a short time in this country Mr. Milne will return to continue his work in London.

J. F. OWENS, president, Oklahoma Gas and Electric Co., announces the election of O. A. Jennings as vice president and commercial manager of the company. Mr. Jennings has been commercial manager of the Oklahoma Gas and Electric Co. since 1919. For 14 yr. prior to that time he was located in Dallas, Texas, as a special representative of the General Electric Co.

J. T. DALCHER, 26 Cortlandt St., New York, formerly manager of the Boiler and Machinery Products Department of Federal Shipbuilding Co., announces that he has made arrangements to supply waste-heat boilers of fire-tube type in a complete line, as an aid to increasing over-all plant efficiency.

EFFECTIVE AUGUST 1, 1931, according to an announcement recently made by the U. S. Postoffice Department, the size limit of parcel post was increased to 100 in., length and girth combined, and the weight limit to 70 lb. for all zones. It is thought that this decision will greatly expand the usefulness of parcel post for it will admit many additional articles to the mails which heretofore have been too large or too heavy to be carried by parcel post.

DAVIS, IOWA, county board of supervisors has authorized the Marshall Electric Co., Marshalltown, Iowa, to erect and operate power lines in Lick Creek township and the company has announced it will construct about 50 mi. of transmission lines this summer, at a cost of $100,000. Franchises for 25 yr. have been granted for operation of three principal lines.

W. F. RABER was elected president of San Diego Consolidated Gas and Electric Co. at a meeting of the board of directors, recently held in San Diego. it has been announced by John J. O'Brien, president, Standard Gas and Electric Co. Mr. Raber has been vice president and general manager of San Diego Consolidated Gas and Electric Co. since 1924.

B. F. STURTEVANT Co. of Hyde Park, Boston, Mass., announces that Walter L. Hunken has been appointed manager of its Greensboro, N. C., office; Philip Cohen has been appointed acting manager of its Cleveland office, and E. A. Engdahl has been appointed manager of its Seattle office.

Books and Catalogs

SUSPENDED TYPE unit cooler and unit humidifier, particularly applicable to plants having humidity control problems, such as the textile industry and printing industry, is described and illustrated in detail in bulletin No. 384 just issued by B. F. Sturtevant Co., Hyde Park, Boston, Mass. This company has also issued bulletin No. 383 describing the humidifilter, an air conditioning unit.

BULL DOG SaftoSwitch-Boards, type DF-30, of standardized sectional construction, totally steel enclosed, with ballbearing switches are described in Architects' and Engineers' Bulletin No. 293 just issued by Bull Dog Electric Products Co., Detroit, Mich.

PICKERING GOVERNORS for all types of steam engines are described in a new 24-page well-illustrated bulletin No. 31, just issued by the Pickering Governor Co., Portland, Conn. Enclosed form of governor, a new feature previously described in Power Plant Engineering is discussed in detail in this bulletin, while applications of the governor either in its original form or in special designs are described and profusely illustrated. The combination form of governor is treated in considerable detail.

LUDLOW MULTI-VALVE, its design, construction and uses in the power plant are treated in bulletin 101 just issued by the Ludlow Valve Manufacturing Co., Troy, N. Y.

CURTISS AND WRIGHT ENGINES and their use of nickel alloy steel is the subject of a new 12-page bulletin issued by the International Nickel Co., Inc., 67 Wall St., New York City, giving complete details of the materials and the design of various parts of these engines.

INFORMATION in the selection of water supply pumps for buildings, with engineering data on pump capacities, tank capacities, etc. is contained in Engineering data sheet No. 1 just issued by Yeomans Brothers Co., 1433 Dayton St., Chicago, Ill.

EDGE MOOR WATER TUBE BOILERS, bent tube types, are described and well illustrated in a 32-page letter-size bulletin, No. 69, just issued by Edge Moor Iron Co., Edge Moor, Del. The bulletin discusses first the construction details of the four drum and three drum bent tube type boilers and horizontal type boilers, gives details of construction and shop practices and concludes with a display of detailed drawings of typical installations of all these types for various firing methods, such as stokers, pulverized coal, gas and oil.

NEW DEVELOPMENTS in Electrical Measuring and Auxiliary Testing Devices, publication No. 128, has just been issued by the Meter Committee, Engineering National Section, National Electric Light Association, 420 Lexington Ave., New York City, price 60 cents to members; 90 cents to non-members. New types of instruments and improvements in existing devices are being brought out by manufacturers to keep pace with the changing demands of the industry. It is the purpose of this report to present information concerning such devices and improvements which have been made available during the year. This report is prepared in two sections, the first dealing with measuring devices and the second with auxiliary equipment. Some of the devices shown have been developed by member companies. The descriptions are necessari'y brief and member companies may obtain further information from the manufacturers.

FIFTY YEARS OF LEADERSHIP is the title of a booklet just issued by the Fisher Governor Co., Marshalltown, Iowa, in commemoration of the 50th anniversary of the company. The bulletin discusses in detail the work of the various departments of the company, showing in detail how its products are manufactured and tested, the discussion being well illustrated by views of the factory.

BULLETIN No. 260, superseding bulletin No. 190, describing Falcon continuous electric furnaces for heat treating ferrous as well as non-ferrous strip metal and wire, has just been issued by H. O. Swoboda, Inc., 3400 Forbes St., Oakland Station, Pittsburgh, Pa.

SHALLCROSS CONTROLS are described in a looseleaf letter-size bulletin just issued by Shallcross Control System Co., Milwaukee, Wis. Data are given on pressure or suction regulators, long distance pressure controls, gas mixing controls, pressure switches, producer gas combustion controls and draft control for furnaces of all types.

THERMIX AIR HEATER, type C, as described in detail in the May 15 issue of Power Plant Engineering, is further described and illustrated in a new bulletin just issued by Prat-Daniel Corp., 183 Madison Ave., New York City.

COMBUSTION ENGINEERING CORP., 200 Madison Avenue, New York, has just issued catalog SG-1, describing the Combustion Steam Generator, a single unit embodying in an integral design the several elements required in the production of steam. Pulverized fuel is introduced at the four corners of a completely water-cooled furnace and is burned with turbulent mixing action. Gases leaving the furnace pass through the superheater at the top of the furnace, thence through a bank of convection tubes and finally through a plate-type air preheater, to the chimney. The well-illustrated catalog includes overall dimensions of the 8 sizes of steam generators.

IN A NEW BULLETIN No. 1270, the Dampney Co. of America, Hyde Park, Boston, Mass., presents an interesting description of the appearance of Apexior coating for boilers both before and after a service run. The condition of the internal surfaces before and after the run are illutsrated and explanation is given of the phenomena observed and the reasons for them.

BULLETIN No. 106 describing Peabody oil burners, gives a description of the burner and details of the advantage of the Peabody wide-range system. It also tells in detail facts regarding operation under natural and forced draft and describes Peabody insulated panel burner front for use with preheated air. Although it illustrates some of the more prominent installations where Peabody equipment is installed, it by no means covers the field where this equipment is applicable and these photographs are but a few representative views. It is a new publication of Peabody Engineering Corp., 40 East 41st St., New York City.

CLEAR RAW WATER ICE Systems and Supplies, is the name of catalog-textbook No. 62 just issued by Jos. A. Martocello & Co., Philadelphia, Pa. The size of this 360-page book is 10½ by 7½ in. and it is divided into six chapters covering the theory and practice of the manufacture of clear ice. One copy will be given to each customer when the request is written on the stationery of the concern making the request. Additional copies will be furnished at $10 each.

REPUBLIC STEEL CORP., Republic Bldg., Youngstown, O., has just issued three booklets of interest to all engineers dealing with iron or steel in any form. The first of these, entitled, Sheet Iron, is a 64-page illustrated booklet telling in non-technical language the story of iron from its early history, describing step by step modern commercial practice from the mines through to the finished product and finishing up with chapters on rust, corrosion and the use and application of special alloys. The second, entitled "Agathon Alloy Steel," is a 132-page booklet

giving complete data on alloy steel and showing the heat treatment of these steels in convenient chart form. These alloys include chrome steel, special combinations of nickel, nickel chrome, nickel molybdenum, chrome vanadium, carbon vanadium and chrome molybdenum. The third, "Toncan Iron Pipe for Permanence," is a 64-page booklet dealing with installations and applications of copper molybdenum iron pipe giving a complete history and the advantages of Toncan iron for this service.

STEEL-BACKED Babbitt-Lined Bearings is the title of a new bulletin recently issued by the Wagner Electric Corp. of St. Louis, Mo. It is known as Wagner Bulletin S-349 and discusses the problem of bearing seizure in electric motors, the superiorities of babbitt bearings and in general the reason Wagner standardizes on steel-backed babbitt-lined bearings for its electric motors.

INSTALLATION of a system of automatic combustion control requires certain mechanical connections between the regulating units of the system and the devices which are to be controlled such as dampers, motor controllers, regulating valves, shafts. The Stiff-Arm Fittings illustrated and described in a new bulletin have been designed and are manufactured by the Carrick Engineering Co., 431 So. Dearborn St., Chicago, Ill., especially for the purpose of providing means for rigidly connecting the controlled devices to the Regulating Units.

TWO-PAGE circular, featuring a new line of potentiometer pyrometers and illustrating six features of this instrument, is issued by The Brown Instrument Co., Philadelphia, Pa.

CONVEYOR BELT PRACTICE is discussed in a 40-page bulletin by The Diamond Rubber Co., Inc., Akron, Ohio. This bulletin gives data on the design of conveyor belts, including information on the number of plies, horsepower, speed, capacity, installations, operating conditions and the like. Similar data are given for elevator belts.

HIGH-EFFICIENCY SPEED REDUCERS of the herringbone, worm and spur gear types are described in detail in a well-illustrated, 60-page catalog, No. 53, just issued by Palmer-Bee Co. Detroit, Mich. Details of construction of these speed reducers are given, accompanied by tables of engineering data, such as horsepower, torque, and tables of dimensions and ratios.

FACTORS effecting grinding wheel selection are discussed in a recent 16-page bulletin by Norton Co., Worcester, Mass.

COMMONWEALTH EDISON CO.'s yearbook for 1931 containing a brief account of the financial status, earnings and expenditures, achievements and progress of the company for 1930 and plans for 1931, has just been issued. The headquarters of the company are 72 W. Adams St., Chicago, Ill.

SEVEN-YEAR operating record of a 15-yr. old Diesel plant at Madison, S. Dak., is given in a recent 12-page bulletin published by Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo. This is reprinted in part from an article by Charles H. Trimmer previously published in Power Plant Engineering and gives comparison of tests in 1915 with the performance in 1930.

GILMER V-BELTS are completely described in a recent 64-page bulletin, presenting details of construction of the belts and sheaves, illustrated discussion of many types of V-belt drives and many tables of engineering data for designing such drives, by L. A. Gilmer Co., Tacony, Philadelphia, Pa.

GENERATED CONTINUOUS-TOOTH herringbone speed reducers and gears are completely described and illustrated in catalog No. 136, a 96-page illustrated booklet just issued by D. O. James Mfg. Co., 1120 West Monroe St., Chicago, Ill. This discusses in detail advantages of continuous tooth herringbone speed reducers, base plates, designs, dimensions, ratings, installations, weights, lubrication and give list price of both double and single type. Corresponding data are given for the generated continuous tooth herringbone gears and the bulletin is well illustrated with details of working parts, views of application and dimension drawings.

NICKEL CAST IRON NEWS, published by the International Nickel Co., 67 Wall St., N. Y. City, contains interesting stories of the use of Ni-Resist for high-pressure castings, machine parts, corrosion resistance, heat resistance at high temperatures and electrical resistance grids.

BULLETIN No. 3132, a 44-page booklet which illustrates and describes turbo-blowers and turbo-compressors, covering the construction and operation of single-stage and multi-stage blowers for discharge pressures of one to 40 lb. and capacities of 3,000 to 100,000 c.f.p.m., and turbo-compressors for discharge pressures up to 110 lb. and capacities of 8,000 to 10,000 c.f.p.m., has just been issued by Ingersoll-Rand Co., 11 Broadway, New York. The booklet contains 37 illustrations, including sectional drawings, charts, blower parts and complete units.

MOTORS, generators, compressers and other electrical and mechanical equipment for power plants and industrial plants are described in bulletin No. 39 just issued by Rockford Power Machinery Co., 639 Seventh St., Rockford, Ill. Complete price lists are given for all these products.

DATA for expansion loops of turns and straight pipe, welded together are given in simplified form in a bulletin No. 106 issued by Tube Turns, Inc., Shelby St., and Goss Ave., Louisville, Ky.

CAR SPOTTERS made by H. W. Caldwell & Son Co., 2410 W. 18th St., Chicago are described and illustrated in a 12-p. booklet recently issued, which gives dimensions, capacities, speeds, power used and pull on rope for various railroad track curvatures.

EXHAUST STEAM turbines for increasing the power and improving the fuel consumption of reciprocating-engined steamships are discussed in a paper by H. Bauer, of Hamburg, Germany, which is being distributed in pamphlet form by the American Bauer-Wach Corporation, 11 Broadway, New York City. This system is characterized by the use of a hydraulic clutch interposed with the speed reducing gears between the turbine shaft and the engine-driven propeller shaft, giving 25 to 30 per cent additional power with no additional expense for fuel, or a saving of about 25 per cent in fuel while developing the same power.

WESTINGHOUSE ELECTRIC and Manufacturing Co. recently has announced three publications covering lightning arresters: Circular 1737-F, titled "Advanced Guards", is a comprehensive, 23-page, illustrated publication describing Autovalve Arresters and, especially, the correct method of installing them. Detailed engineering discussions supplemented by drawings and diagrams clarify many problems of arrester installation. Leaflet 20013-K describes, with the aid of illustrations, the operation, construction and method of installation of Type LV Autovalve Arresters for the protection of distribution transformers; and includes tables enabling the selection of the type of arrester suitable for a given application. In Leaflet 20149-G, Type SV Autovalve Arresters for station use either indoors or outdoors, are described as to construction and operation.

A 16-PAGE PUBLICATION entitled, Westinghouse Arc Welding Data Bulletin No. 15, has recently been announced. This booklet contains illustrations of many unusual arc welding achievements, explains with the aid of diagrams various methods of testing, and discusses methods for obtaining good welds. Copies of this publication (D.M.F. 5350) may be obtained from the nearest Westinghouse district office.

THE STEEL TANK MERCURY-ARC RECTIFIER, which converts alternating to direct current over wide ranges of both voltage and current, is announced by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. The most general use of this equipment is in supplying power for electric traction system, although it has certain industrial applications. For some electro-chemical processes, the power supply requirements are such that rectifiers provide the preferable means of conversion. Circular 1907, issued by the company, describes these rectifiers in detail and includes many photographs and drawings of the complete apparatus and of the various parts entering into it.

"FULLER LEHIGH CIRCULAR BURNER" is the title of a new bulletin, No. 905, recently issued by the Fuller Lehigh Co., 85 Liberty St., New York, N. Y. The Circular Burner, a pulverized coal burner of the turbulent type, is widely used for firing pulverized-coal through solid refractory furnace walls with a minimum of alterations.

The new bulletin describes the application, construction and operation of the Fuller Lehigh Circular Burner and copies of it may be obtained directly from the company.

HEAT TRANSFER APPARATUS for process work is described in a bulletin which has just been published by The Griscom-Russell Co., 285 Madison Ave., New York City. This bulletin illustrates the many types of condensers, coolers, heat exchangers, heaters and evaporators manufactured by the company with references to bulletins in which each design is fully described. The equipment illustrated has a wide range of application for transfer of heat between liquids, gases and vapors of every kind, for recovery of waste heat by using hot fluids to heat up incoming cold liquids and for the production of pure distilled water for boiler feed and other purposes from any source of raw water. The bulletin also describes the new G-Weld process to provides homogeneous, ductile, strong bonds for pressure vessels, used on Griscom-Russell shells for high pressures and temperatures.

NEW MORSE MIDGET COUPLING is described in detail in bulletin No. 40 just issued by Morse Chain Co., Ithaca, N. Y.

Power Plant Construction News

Calif., Los Angeles—The Curtis Mfg. Co., Lane Mortgage Building, Los Angeles, plans installation of electric power equipment in proposed new plant unit, 200x575 feet, entire project reported to cost over $100,000. Vernon W. Houghton, 617 North New Hampshire Street, is architect.

Calif., Los Angeles—The Loose-Wiles Biscuit Co., 1100 West Eighth Street, Kansas City, Mo., plans installation of electric power equipment, ovens and other mechanical equipment in proposed new plant in vicinity of Los Angeles, reported to cost close to $1,000,000.

Calif., San Dimas—The Randolph Packing Co. plans installation of electric power equipment in connection with proposed rebuilding of portion of fruit packing plant recently damaged by fire with total loss reported in excess of $200,000.

Calif., Vernon—The Globe Grain & Milling Co., 907 East Third Street, Los Angeles, Calif., plans installation of electric power equipment in connection with proposed rebuilding of grain and flour mill at Vernon, recently destroyed by fire with loss reported in excess of $300,000.

D. C., Washington—The Potomac Electric Power Co., Washington, has purchased a tract of land in southwestern part of city, in vicinity of T, U and V Streets, fronting on James Creek Canal, and is said to be planning to use site for proposed new steam-operated electric generating plant to cost more than $3,500,000, with transmission system.

Fla., Milton—The Peoples Ice Co., North Tarragono Street, Pensacola, Fla., is said to have plans under way for a new ice-manufacturing plant at Milton, reported to cost over $35,000, with equipment. Machinery will be electrically operated.

Fla., Tampa—The Poinsettia Dairy Products, Inc., Marion and Cass Streets, plans installation of electric power equipment in proposed new plant unit on local site, entire project reported to cost close to $100,000. Frank A. Winn, Jr., 207 Twiggs Street, Tampa, is architect.

Fla., Tampa—The Evans Products Co., Union Guarantee Building, Detroit, Mich., plans installation of electric power equipment in proposed new crate-manufacturing plant at Tampa, for citrus fruit service, reported to cost over $200,000. A boiler plant is projected.

Ind., Indianapolis—The Melaun Mfg. Co., 144 East Morris Street, plans installation of electric motors and other power equipment in a proposed new addition to metal stamping works.

Ky., Louisville—The Louisville Gas & Electric Co., Louisville, is planning extensions and improvements in local power substation and transmission lines, reported to cost over $400,000. Company engineering department is in charge.

La., Ruston—The City Council is arranging for a bond issue of $180,000, for the installation of a municipal natural gas system, including compressor stations and other operating equipment.

La., Sterlington—The Louisiana Power & Light Co., New Orleans, La., is planning construction of a transmission line from its generating station at Sterlington to Hodge, La., for power service at mill of the Southern Advance Bag & Paper Co., at last noted place. Line will be about 25 miles long and is reported to cost close to $90,000, with substation facilities at paper mill.

Mich., Ontonogan—The Bond Falls Hydro-Electric Co., care of Harry A. Bond, 920 South Madison Street, Green Bay, Wis., now being organized by Mr. Bond and associates, is considering the construction of a hydro-electric power station on a branch of the Ontonogan River, near Ontonogan, reported to cost over $150,000.

Mich., Detroit—The Chrysler Corporation, 341 Massachusetts Avenue, plans installation of electric power equipment in proposed new addition to automobile manufacturing plant on Mount Elliott Avenue, entire project to cost close to $100,000.

Miss., Jackson—Dixie Glass Bottle Mfg. Co., New Merchants Bank Building, plans installation of electric power equipment in new bottle-manufacturing plant, estimated to cost close to $100,000. Company engineering department is in charge.

Mo., Huntsville—The City Council is said to be planning installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in municipal waterworks to cost about $25,000. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Neb., South Sioux City—The Central West Public Service Co., Sioux City, Iowa, is considering a new ice-manufacturing plant at South Sioux City, to cost over $85,000, to replace a plant unit recently damaged by fire.

N. J., Cape May Court House—The Colonial Knitting Mills, Inc., B and Clearfield Streets, Philadelphia, Pa., plans installation of electric power equipment in proposed new knitting mill on site recently acquired at Cape May Court House, entire project reported to cost close to $150,000. It is proposed to build a boiler plant.

N. J., Woodbridge—A group of nine municipalities is planning the construction of a sewage disposal plant for the Rahway Valley trunk sewer, estimated to cost $375,000 with pumping machinery and other mechanical equipment. Clyde W. Potts, 30 Church Street, New York, consulting engineer, is in charge of project. The different cities include Woodbridge, Rahway, Westfield, Cranford, Springfield, Kenilworth, Roselle Park, Clark Township and Garwood.

N. C., Asheboro—The Cranford Chair Co., Asheboro, plans installation of electric power equipment in new two-story addition to plant, designed to double present output, reported to cost close to $50,000. Work will be placed under way at at once.

Ohio, Girard—The Western Reserve Lumber Co., Girard, plans installation of electric power equipment in connection with proposed rebuilding of portion of planing mill recently damaged by fire with loss of about $40,000.

Okla., Heavener—The Common Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in municipal waterworks, entire project reported to cost about $75,000. V. V. Long & Co., Colcord Building, Oklahoma City, Okla., are engineers.

Okla., Pawhuska—The Common Council has approved a fund of $46,762 for extensions and improvements in municipal electric light and power plant, including installation of a new engine unit and auxiliary equipment.

Pa., Freeport—The A. M. Smith Co., Freeport, is considering rebuilding of portion of ice-manufacturing plant recently destroyed by fire with loss reported at close to $25,000, including equipment.

Pa., Warren—The United Refining Co., Warren, plans installation of tanks and power equipment in connection with proposed rebuilding of portion of oil refining plant, recently damaged by fire with loss reported in excess of $50,000.

Texas, Gladewater—The Humble Oil & Refining Co., Houston, Tex., plans installation of pumping machinery and other power equipment in proposed new oil refining plant at Gladewater, entire project to cost over $150,000. A boiler house is planned.

Texas, Jasper—The Jasper Veneering & Mfg. Co., Jasper, plans installation of electric motors and other power equipment in proposed new crate manufacturing plant, entire project reported to cost over $45,000.

Texas, Kilgore—The Woodley Petroleum Co., Kilgore, plans installation of pumping machinery and other power equipment in proposed new oil refining plant on site about 3 miles from city, entire project reported to cost over $90,000.

Texas, Rule—The Rule Oil Mill Co., Rule, plans installation of electric power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss reported at close to $90,000.

Wash., Okanogan—The Pacific States Pulp & Paper Co., Priest River, Idaho, plans installation of electric power equipment in proposed new sodium sulphate plant in the vicinity of Okanogan, entire project reported to cost about $75,000.

Wash., Prosser—The Bureau of Reclamation, Denver, Colo., has plans nearing completion for power plant and equipment at Prosser, in connection with reclamation project, and is expected to ask bids at an early date. Bids are also scheduled to be called in near future for a pumping plant in the vicinity of Kennewick, Wash., for the same project.